COAST GUARD

BULLETIN NO. 56

Report of the International Ice Patrol Service in the North Atlantic Ocean

SEASON OF 1970

CG–188–25

NOTE

Report of the International Ice Patrol Service in the North Atlantic Ocean, Season of 1968, CG–188–23, and *Report of the International Ice Patrol Service in the North Atlantic Ocean*, Season of 1966, CG–188–21, incorrectly report the iceberg counts for the season of 1960. The correct count for the season of 1960 should be as given below.

Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
0	0	2	3	3	0	0	33	54	44	4	0	143

The report for 1968 also reports the 1900–1968 May average iceberg count as 24.0. This figure should be 124.0. New totals and averages reflecting the corrected 1960 data are included in this report.

Figure 16D of *Report of the International Ice Patrol Service in the North Atlantic Ocean*, Season of 1969, CG–188–24, is incorrectly labeled. The charts labeled "Normal May" and "May 1969" should have been labeled "Normal June" and "June 1969." Similarly, the two charts labeled June should have been labeled May.

DEPARTMENT OF TRANSPORTATION

UNITED STATES COAST GUARD

Address reply to:
Commandant (OMS)
U.S. Coast Guard
Washington, D.C.
20590

28 September 1971

Transmitted herewith is *Report of the International Ice Patrol Service in the North Atlantic Ocean, Season of 1970.*

R. E. HAMMOND
Chief, Office of Operations.

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PREFACE

This report is 56th in a series of annual reports on the International Ice Patrol Service in the North Atlantic Ocean. It contains information on Ice Patrol organization, communications, and operations, on ice and environmental conditions and their relationship in 1970, and an analysis of preseason iceberg surveys made by the U.S. Coast Guard since 1948.

The authors of the report acknowledge ice and weather data supplied by the Canadian Department of Transport, weather data supplied by the U.S. National Weather Service, and oceanographic data supplied by the U.S. Coast Guard Oceanographic Unit. Acknowledgement is also made to Yeoman Second Class Roy J. MOFFETT, USCG, Marine Science Technician Third Class John D. JENNE, USCG, and Marine Science Technician Third Class Robert O. LAPREY, USCG, for assistance in the preparation of the manuscript and illustrations for this report.

INTERNATIONAL ICE PATROL, 1970

The 1970 International Ice Patrol Service in the North Atlantic Ocean was conducted by the U.S. Coast Guard under the provisions of Title 46, United States Code, Sections 738, 738a through 738d, and the International Convention for the Safety of Life at Sea, 1960, Regulations 5 through 8. The International Ice Patrol is a service for observing and disseminating information on ice conditions in the North Atlantic. During the ice season, the southeastern, southern, and southwestern limits of the regions of icebergs in the vicinity of the Grand Banks of Newfoundland are guarded for the purpose of informing passing ships of the extent of this dangerous region. The International Ice Patrol also studies ice conditions in general, and affords assistance to ships and crews requiring aid within the limits of operation of Ice Patrol forces.

The International Ice Patrol is directed from the Ice Patrol Office located on U.S. Coast Guard Base, Governors Island, New York. The Ice Patrol Office gathers ice and other environmental reports from various sources, maintains an ice plot, forecasts ice conditions, prepares the Ice Bulletin, answers requests for special ice information, and maintains operations control of the Ice Reconnaissance Detachment, the Ice Patrol oceanographic ship and the Surface Patrol ship when assigned.

Responsibility as Commander, International Ice Patrol, was held as indicated below:

Rear Admiral Mark A. WHALEN, USCG —until 1 June 1970

Captain James M. McLAUGHLIN, USCG 1–29 June 1970.

Rear Admiral Benjamin F. ENGEL, USCG —after 29 June 1970

Commander James R. KELLY, USCG, was directly responsible for the management of the Patrol.

Preseason Ice Patrol flights were made in September and December, 1969, and in January, February, and March, 1970. In February 1970, the Ice Patrol was notified that the U.S. Naval Station at Argentia, Newfoundland, would be "phased down" in the spring of 1970. In the past the station had been the site of Ice Patrol Radio Station N1K and the airfield from which the Ice Reconnaissance Detachment operated.

The Ice Reconnaissance Detachment deployed to Argentia on 17 March, then redeployed to Canadian Forces Base Summerside, Prince Edward Island, on 30 April. The detachment returned to the United States on 24 July.

The 1970 ice season officially commenced at 0000 GMT 24 March when the first Ice Bulletin was issued, and continued until 25 July. The twice daily Ice Bulletin was broadcast by International Ice Patrol Radio Station, Boston/NIK, U.S. Naval Radio Station, Washington/NSS, Canadian Forces Radio Station, Mill Cove/CFH, and Canadian Coastal Radio Station, St. Johns/VON. Commencing 11 June the Ice Bulletin was included on the U.S. Marine Information Broadcast for the High Seas of the North Atlantic, a voice broadcast. The facsimile ice chart was unable to be transmitted during the 1970 season.

The USCGC *Evergreen*, commanded by Lieutenant Commander Robert E. PHELPS, USCG, conducted oceanographic cruises for the Ice Patrol during the periods 1–27 April, and 13 May–6 June. For the eleventh consecutive year it was unnecessary to use a surface patrol ship.

During the 1970 season 85 icebergs drifted south of 48N, a relatively light season.

AERIAL ICE RECONNAISSANCE

During the period 1 September 1969 to 31 August 1970, a total of 78 ice observation flights were made. Preseason flights made in September, December, January, February, and March accounted for 18 flights, and 60 flights made during the season accounted for the remainder. The purpose of the preseason flights was to study iceberg distribution patterns in Baffin Bay and the Labrador Sea, and to evaluate the iceberg potential of the developing ice season. The purpose of the flights during the season was to guard the southeastern, southern, and southwestern limits of icebergs, to evaluate the short term iceberg potential of the waters immediately north of the Grand Banks, and occasionally to study the iceberg distribution along the Labrador coast. Flight statistics are shown in table 1, and are exclusive of time required to deploy from U.S. Coast Guard Air Station, Elizabeth City, to the operating base.

Aerial ice reconnaissance was accomplished by U.S. Coast Guard Lockheed HC130B aircraft from the U.S. Coast Guard Air Station at Elizabeth City, North Carolina. During the preseason flights the aircraft operated from U.S. Naval Station Argentia, Newfoundland; U.S. Air Force Base Goose Bay, Labrador; U.S. Air Force Base Sondrestrom, Greenland; and U.S. Air Force Base Thule, Greenland. During the iceberg season Ice Patrol aircraft have in the past operated from U.S. Naval Station Argentia, however in February 1970 it was announced that operations there were to be phased down, and it became necessary to locate another airfield from which to operate, thus terminating the long and fruitful association of the International Ice Patrol with the Naval Station. This association dates back to the postwar reactivation of the International Ice Patrol in 1946 when two U.S. Coast Guard PB4Y-1 Liberators, based at the U.S. Naval Operating Base, Argentia, became the first Ice Patrol reconnaissance aircraft.

Table 1.—**Aerial Ice Reconnaissance Statistics—September 1969 August 1970**

Month	Number of flights	Flight hours
PRESEASON		
September	5	30.9
October	0	0
November	0	0
December	3	20.0
January	3	15.0
February	2	12.3
March (through 23d)	5	25.4
Preseason totals	18	103.6
SEASON		
March (from 24th)	5	24.3
April	17	96.9
May	15	105.1
June	14	84.5
July (through 24th)	9	61.9
Season totals	60	372.7
POSTSEASON		
July (from 25th)	0	0
August	0	0
Postseason totals	0	0
Annual totals	78	476.3

After consideration of several alternatives it was decided to operate from the Naval Station in 1970 until instrument landing facilities were discontinued, and then to deploy to Canadian Forces Base Summerside, Prince Edward Island, for the remainder of the season.

On 17 March the Ice Reconnaissance Detachment deployed to Argentia from Elizabeth City and operated there until 30 April when the move was made to Summerside. Summerside, approximately 500 miles west of the Grand Banks, was the operating base for the Ice Reconnaissance Detachment until 24 July when it returned to the United States.

The generosity and cooperation of the Canadian Forces in permitting the International Ice Patrol to operate from their base at Summerside is gratefully acknowledged. In spite of the distance from the patrol area Ice Patrol operations were conducted smoothly from Summerside. This was certainly due in large measure to the excellent logistic and communication support provided by the Canadian Forces, as well as their efforts to make the Ice Patrol feel genuinely welcome.

COMMUNICATIONS

Ice Patrol communications included reports of ice and environmental conditions, Ice Bulletins, voice broadcasts, and administrative traffic necessary to operate the patrol. The Ice Bulletin was disseminated by teletype from the Ice Patrol office in New York to about 28 addresses, including the Naval Oceanographic Office, the Canadian Department of Transport, the British Admiralty, and cooperating radio stations. International Ice Patrol Ice Bulletins were broadcast twice daily by Coast Guard Radio Station, Boston/NMF/NIK, U.S. Naval Radio Station, Washington/NSS, Canadian Coastal Radio Station, St. John's/VON, and Canadian Maritime Radio Station, Mill Cove/CFH. The Ice Bulletins disseminated this year made no reference to the effective lane of the North American Atlantic Lane Track Agreement. This was because the agreement, which had been in existence since 1890, was abrogated by the contracting parties effective 1 September 1969.

The phase down of the U.S. Naval Station at Argentia and the resulting closure of the Coast Guard Radio Station, Argentia, NJN/NIK, necessitated a number of changes in Ice Patrol communications. Coast Guard Radio Station, Boston/NMF, assumed most of the duties of Ice Patrol Radio Station/NIK, transmitting the Ice Bulletin to shipping daily at 0018 GMT and 1218 GMT. Each transmission was preceded by a simultaneous "CQ" call on 5320, 8502, and 12750 kHz. After a 2-minute series of test signals transmitted on these frequencies, NMF/NIK transmitted the Ice Bulletin first at 25 words per minute and then at 15 words per minute.

A new service of the Ice Patrol was inaugurated 11 June 1970, when a voice summary of the International Ice Patrol Bulletin was included as part of the United States Marine Information Broadcast for the High Seas of the North Atlantic. This summary was broadcast daily by Coast Guard Radio Station, Boston/NMF, on 7865.4 kHz (8764.0) upper sideband mode commencing at 0130, 0730, 1330, and 1930 GMT and on 8764.0 kHz double side band mode commencing at 0149, 0749, 1349, and 1949 GMT. After 24 June 1970, the NMF double side band broadcasts were made at 0200, 0800, 1400, and 2000 GMT.

Merchant ships calling to transmit Ice Patrol traffic were requested to use the regularly assigned international call signs of the Coast Guard Ocean Station, East Coast AMVER Radio Stations, or Canadian Coastal Radio Station, St. John's. Coast Guard Stations were alert to answer NIK/NJN/NIDK calls, if used. When communicating with the above stations, merchant ships were requested to call and pass traffic as shown in table 2.

Table 2.—Communications With International Ice Patrol

Purpose	*Frequencies which should be used*
Calling	500 kHz (if 500 kHz is being used for distress traffic then 512 kHz may be used as supplementary calling frequency), 2182 kHz (voice) assigned HF (CW) calling frequencies.
Transmission of traffic by merchant vessels	Assigned MF, 2 MHz (voice), HF (CW) maritime mobile working frequencies.
Transmission of traffic by the following Coast Guard Stations:	
Ocean Station Vessels 4YB, 4YC, 4YD, 4YE, 4YH	466 kHz (CW), 2670 kHz (voice).
AMVER Radio Stations:	
NMF (Boston)	472, 8465 kHz (CW).
NMY (New York)	486, 2670, 12718.5, 17002.4 kHz (CW).
NMN (Norfolk-Portsmouth)	466, 2670. 8465 kHz (CW).
Transmission of traffic by Canadian Coastal Radio Station, St. Johns/VON	478 kHz (CW).

Communication statistics for the period 1 September 1969, through 31 August 1970, are shown in table 3.

Table 3.—Communication Statistics

Number of Ice Reports received from ships	439
Number of Sea Surface Temperature Reports received from ships	1,014
Number of ships requesting special information	22
Number of Ice Bulletins issued	248

ICE CONDITIONS, 1970 SEASON

September-December

After the close of the 1969 Ice Patrol season occasional icebergs continued to drift south along the Labrador coast. During September there were eight reports of iceberg sightings, all north of the Strait of Belle Isle. Occasional reports continued to be received throughout October, November, and December, including one large iceberg reported in the vicinity of Fogo Island on 1 November. On 13 November there was a report of an iceberg sighted midway between Cape Farewell, Greenland, and Goose Bay, Labrador. It is uncertain whether this iceberg came from east Greenland or Baffin Bay. There were several reports of iceberg sightings southeast of Cape Farewell, Greenland, as far offshore as 270 miles. Although iceberg sightings this far southeast of Greenland are relatively infrequent, they are by no means rare.

During the period 18–23 September 1969, a preseason iceberg survey was made of the Labrador coast and Baffin Bay. The purpose of the survey was to study iceberg distribution patterns and to assess the iceberg potential for the coming season. The number of icebergs counted per one degree rectangle is shown in figure 1. The count in the area between Cape Dyer and Cape Christian off the Baffin Island coast was about 85% higher than the 1964–69 average count of 364 in this area, thus indicating that the iceberg potential for a heavy iceberg season on the Grand Banks in 1970 was good.

A preseason flight along the Labrador coast and into southwestern Baffin Bay was also conducted during the period 11–16 December. The iceberg counts on this survey are shown in figure 2. Counts in the area offshore Baffin Island between Cape Dyer and Cape Christian were about 90% higher than the 1963–69 average of 257. Counts in the area between Hudson Strait and Cape Dyer were about 30% higher than the 1963–69 average of 201. The counts in both of these areas continued to indicate a heavier than normal iceberg season on the Grand Banks. Sea ice was encountered during the December survey about 60 miles south of Hudson Strait.

January

Only three icebergs were reported to the Ice Patrol office in January. All three were north of 56N. One was approximately 60 miles off the Labrador coast at 56N, one was near Ocean Station Bravo, and the third was about 100 miles south of Cape Farewell, Greenland. During the period 20–24 January a preseason flight was made along the Labrador and Baffin Island coasts as far north Cape Dyer. The results of this flight are shown in figure 3. Counts in the area between Hudson Strait and Cumberland Sound were about the same as the 1963–70 average of 162. Counts south of Hudson Strait were about 90% higher than the 1963–70 average of 80. At the time of the January survey sea ice was beginning to drift across the approaches to the Strait of Belle Isle.

February

During February 1970 occasional reports of icebergs or growlers were made by Coast Guard ships enroute or on Ocean Station Bravo. The southermost of these reports was a growler reported at about 52–00N 51–30W on 16 February. A group of six icebergs was also reported at 57–00N 49–10W by an aircraft on 2 February. A preseason iceberg reconnaissance was made along the Labrador coast during the period 27 February–4 March. The results of the survey are discussed in the section on March ice conditions.

March

By early March, sea ice extended from the general area of Fogo Island and Cape Freels northeastward to about 52N, and then generally ran northward paralelling the Labrador coast about 150 to 180 miles offshore. The final leg of the preseason iceberg survey started in late February was completed on 4 March with a flight from Goose Bay to Argentia. Unfortunately the visibility was bad south of 53N on this flight.

However many radar targets were observed during this portion of the flight, and in view of a 2 March report of two icebergs near 52–10N 51–30W, all of the radar targets were evaluated as icebergs although some may undoubtedly have been ships in the sealing fleet. The results of the survey between 27 February and 4 March are shown in figure 4. Counts in the area between Hamilton Inlet, Labrador and Hudson Strait were about 95% higher than the 1963–70 average of 300 icebergs. Counts south of Hamilton Inlet were about 5% lower than the 1963–70 average of about 62 icebergs. On the basis of the above average number of icebergs sighted on this survey a special iceberg bulletin forecasting a heavy iceberg season on the Grand Banks was issued on 9 March.

A series of preseason flights between 18 and 20 March showed that sea ice extended past Cape Freels to about 49N, and that icebergs were located in two general groupings; one in the sea ice centered near 51N 54W, the other as a group of radar targets east of the sea ice centered near 51–40N 52–00W. A lone growler was observed outside the sea ice in position 49–50N 50–20W. The observations made on these flights are shown in figure 5. By the end of March the icebergs previously sighted in sea ice had moved as far south as 49–50N and the group outside the sea ice, now positively identified as icebergs, had moved south to about 51–00N 51–00W. This is shown in figure 6 which shows the results of a series of flights made 26–29 March. Between the beginning and end of March the sea ice did not appreciably change in its southern extent; however it did move about 50 miles westward toward Cape Freels. Throughout most of the middle and end of March there was generally open water to be found in the form of wide shore leads between Cape Freels and White Bay. The maximum extent of sea ice in March is approximately as shown in figure 6. This is considerably less than the 1898–1938 average extent shown in the Ice Atlas of the Northern Hemisphere published by the U.S. Naval Oceanographic Office. For comparison the average sea ice extent for March is also shown in figure 6. It is estimated that no icebergs drifted south of 48N in March 1970.

April

By the end of the first week of April sea ice was found south of Cape Bonavista to about latitude 48–20N, and extended as far east as 51–00W. This was a net movement of about 50 miles southeastward from its position during the series of flights in late March. A number of icebergs and growlers were found along and south of the sea ice edge by the end of the first week of April. See figure 7. The icebergs shown in figure 7 are believed to be those found inside the sea ice during the last part of March. By mid-April the eastern limit of sea ice had retreated to about 53–00W, maintaining the same southward extent to between 48–00N and 49–00N. By this time a few growlers were poised slightly north of 48N along the Newfoundland coast, as shown in figure 8. Throughout the remainder of the month sea ice continued to withdraw northwestward. By 20 April Cape Freels was clear of sea ice, and by the end of the month half of Notre Dame Bay was clear as far north as Fogo Island. As the sea ice withdrew a few icebergs began to drift south along the Avalon Peninsula, as revealed by iceberg reports received during the latter part of April. See figure 9. The first iceberg found south of 48N was reported on 21 April by the Ice Reconnaissance Detachment at 47–20N 52–25W. It is estimated that approximately five icebergs drifted south of 48N during April. Four of these drifted along the Avalon Peninsula and evidently melted within 60 miles south of Cape Race. The fifth iceberg was reported in position 47–20N 50–50W on 1 May, having drifted south of 48N a few days previously. Numerous radar targets were reported on the northern Grand Banks in latter April; however it is believed that few, if any, of these were icebergs, but rather were passing ships. The maximum extent of sea ice for April 1970 was that found during the first week as shown in figure 7. Comparison with the Ice Atlas average for April reveals that there was much less sea ice than normal in April 1970.

May

Throughout May the southern limit of sea ice hovered northeast of Cape Bonavista, Newfoundland, and a fairly extensive shore lead was usually present between Cape Freels and the Notre Dame Bay area. By the end of the month the southern sea ice limit had withdrawn to approximately 45 miles north of Cape Freels. During the first half of May the sea ice limits were generally to the west of 53W. During the later half of the month the width of the ice off Belle Isle

Strait increased until it extended as far east as 51W. The maximum extent of sea ice in May is shown approximately in figure 10. Flight operations during the first half of May were hampered by poor visibility in the iceberg patrol areas and definite information on the iceberg threat during this period is sketchy. Comparing the information obtained on the good series of flights on 16–18 April with the next good series on 17–20 May, it appears that the net movement of icebergs between mid-April and mid-May was only from near 49–30N 53–00W to the southern edge of the sea ice near 49N 52W (figure 10). Many radar targets were reported in the Grand Banks area during the first half of the month, however, it is believed that very few of them were icebergs. The only positive indication that some of the radar targets may have been icebergs drifting in advance of the general mass of icebergs further north was a ship report of an iceberg near 48–00N 49–00W on 16 May. The few icebergs that had drifted to the Cape Race area in late April were last seen on 1 May. They evidently melted during early May, and no other icebergs are believed to have been present in the vicinity of the Avalon Peninsula during May. During the last few days of May, icebergs began to drift south and east of Cape Bonavista. On 30 May about 25 icebergs and several growlers were reported strung out to 200 miles eastward of Trinity Bay. It is estimated that only two icebergs drifted south of 48N during the month of May 1970.

June

The month of June saw the only significant threat by icebergs to the Grand Banks area. Flights on 5 and 6 June (see figure 11) indicated that the icebergs sighted strung out eastward on the flight of 30 May were beginning to drift down the eastern slopes of the Grand Banks. On 7 June there were numerous reports from shipping of icebergs in the general vicinity of 48N 48W, as well as reports of icebergs near 46N 47W. Icebergs continued to drift south, and on 10 June an iceberg was reported at position 45–35N 47–45W. This iceberg, shown on figure 13, was the southernmost reported iceberg for the 1970 season and was about 120 miles north of the 1946–65 average position of the southernmost iceberg of the season. A series of flights on 14, 15, and 16 June covered most of the area between 43–20N and 49–00N, and showed that there were approximately 12 icebergs to be found south of 48N, and approximately 80 icebergs strung out towards the east from Newfoundland between 48–00N and 49–00N (see figure 12). A flight on 27 June found approximately 100 icebergs between 48–30N and 50–00N, thus indicating that there were still icebergs to be found on routes into the Strait of Belle Isle as of late June when sea ice had cleared from the entrance to the Strait enough so that shipping could pass through the Strait.

It is estimated that approximately 70 icebergs drifted south of 48N during the month of June.

At the beginning of June the southern extent of sea ice was to approximately 50N. By the end of June all sea ice had cleared to north of Belle Isle Strait. Sea ice conditions during June were approximately normal in comparison to the Ice Atlas.

July

Flight operations in early July were hampered by poor visibility. However, based on ship reports and occasional flights it became apparent that very few icebergs were drifting south of 48N, although reports from shipping through Belle Isle Strait indicated that there were numerous icebergs still to be found north of 51N. A series of flights between 19 and 23 July, see figure 13, and reports from shipping indicated that there was little iceberg threat remaining for the Grand Banks during the 1970 season. The easternmost iceberg observed during the 1970 season was found on 3 July at 48–50N 44–15W, somewhat less to the east than the 1946–65 average. It is estimated that 8 icebergs drifted south of 48N during the month of July. There was no known sea ice south of Belle Isle Strait.

August

During August there were three reports of icebergs between 48–00 and 50–00N as well as numerous reports of icebergs in the approaches to the Strait of Belle Isle. There were no known icebergs south of 48N in August.

Table 4.—**Estimated Number of Icebergs South of Latitude 48°N, Season of 1970**

Season	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1970	0	0	0	0	0	0	0	5	2	70	8	0	85
Average 1900-1945	5	2	2	2	3	10	46	105	154	76	26	8	440
Total 1946-1970	5	2	4	5	10	87	545	1,846	1,519	1,061	235	12	5,331
Average 1946-1970	0	0	0	0	0	3	22	74	62	42	9	1	229
Total, 1900-1970	251	109	110	85	130	538	2,647	6,691	8,602	4,579	1,431	401	25,574
Average 1900-1970	4	2	2	1	2	8	38	94	121	64	20	6	361

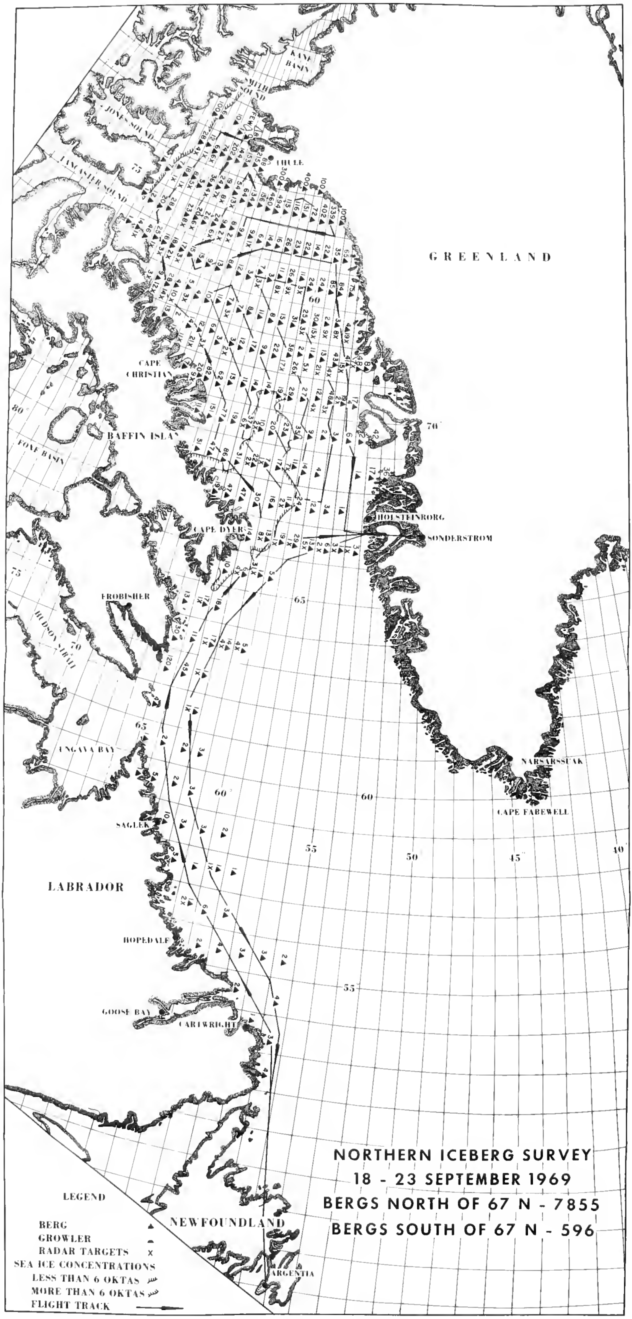

Figure 1.—Northern Iceberg Survey, 18-23 September 1969

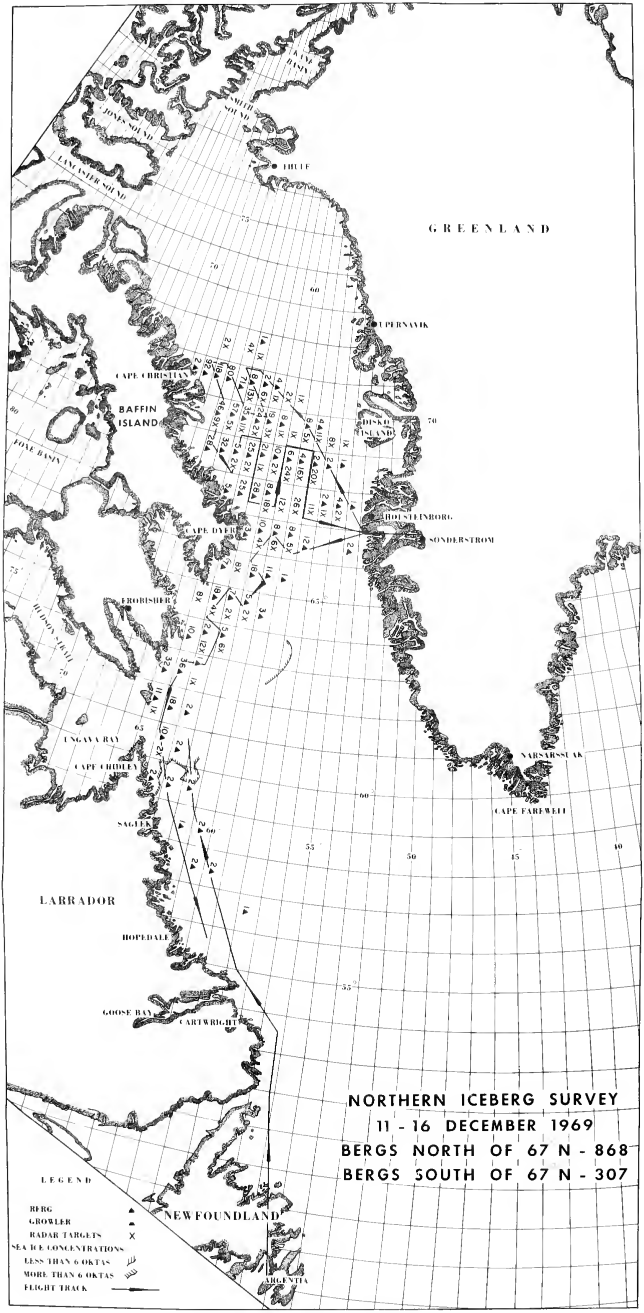

Figure 2 —Northern Iceberg Survey, 11-16 December 1969

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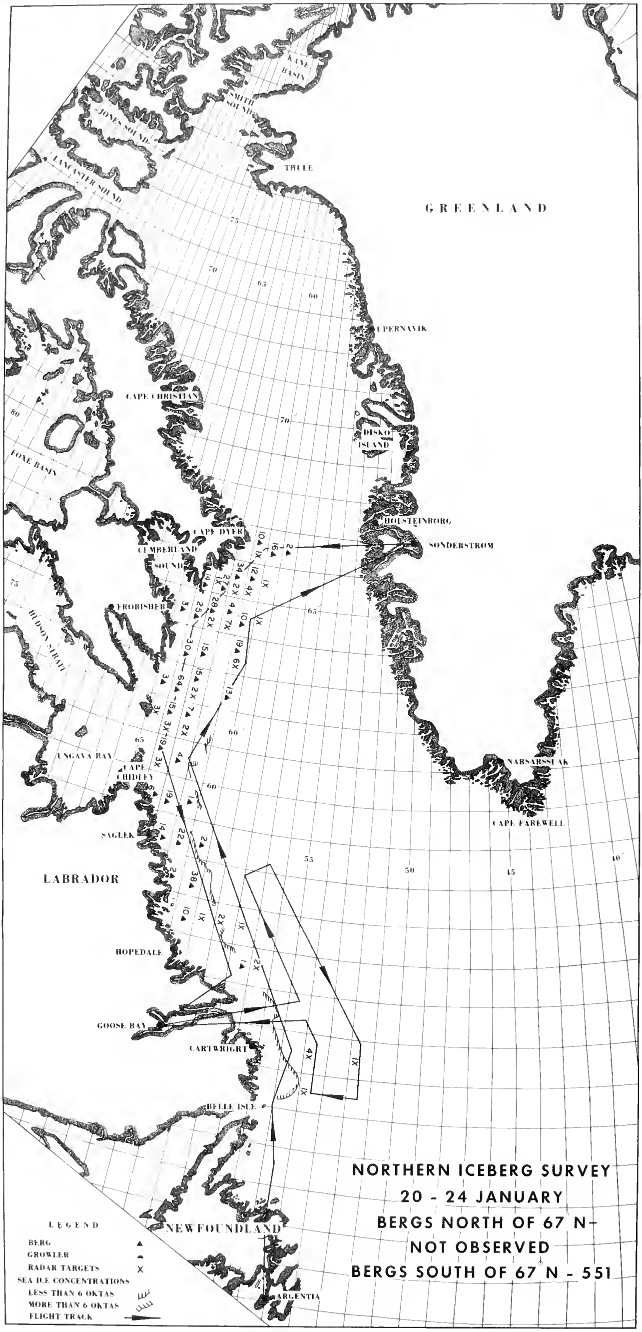

Figure 3.—Northern Iceberg Survey, 20-24 January 1970

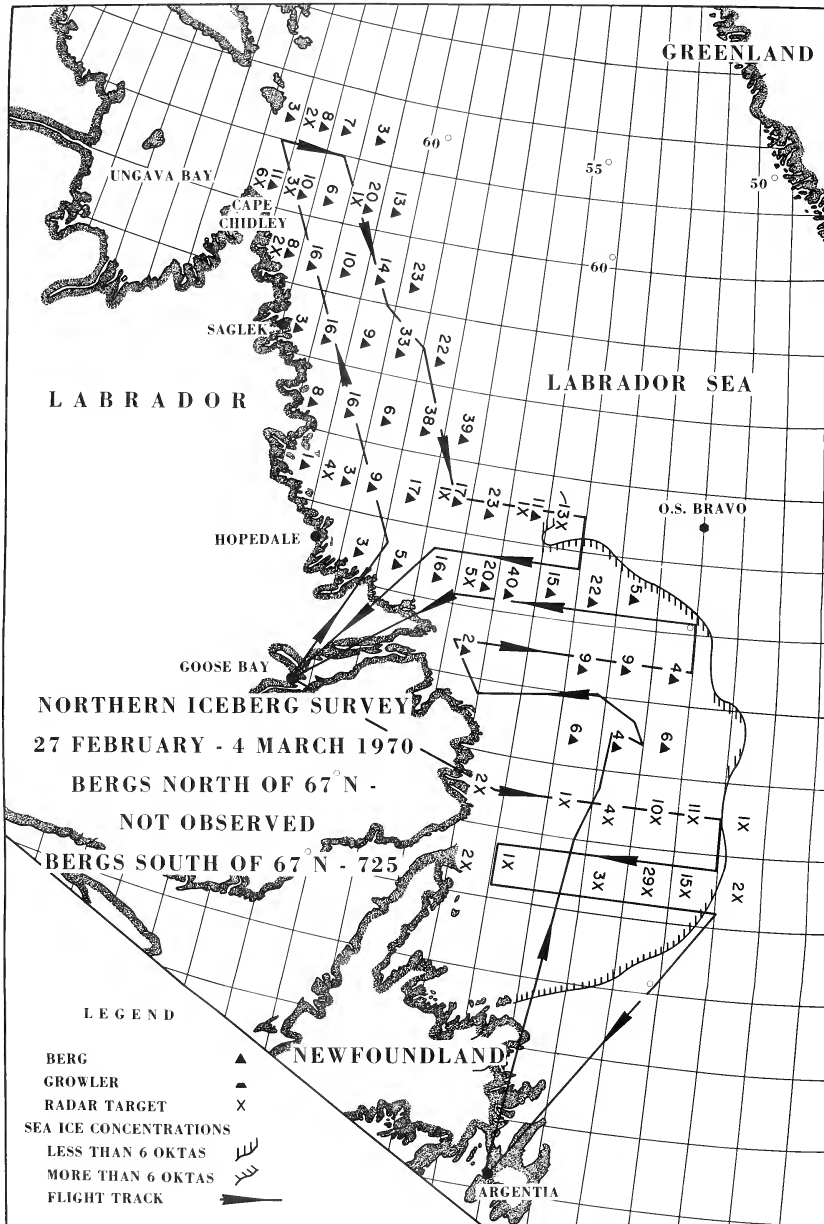

Figure 4.—Northern Iceberg Survey, 27 February-4 March 1970.

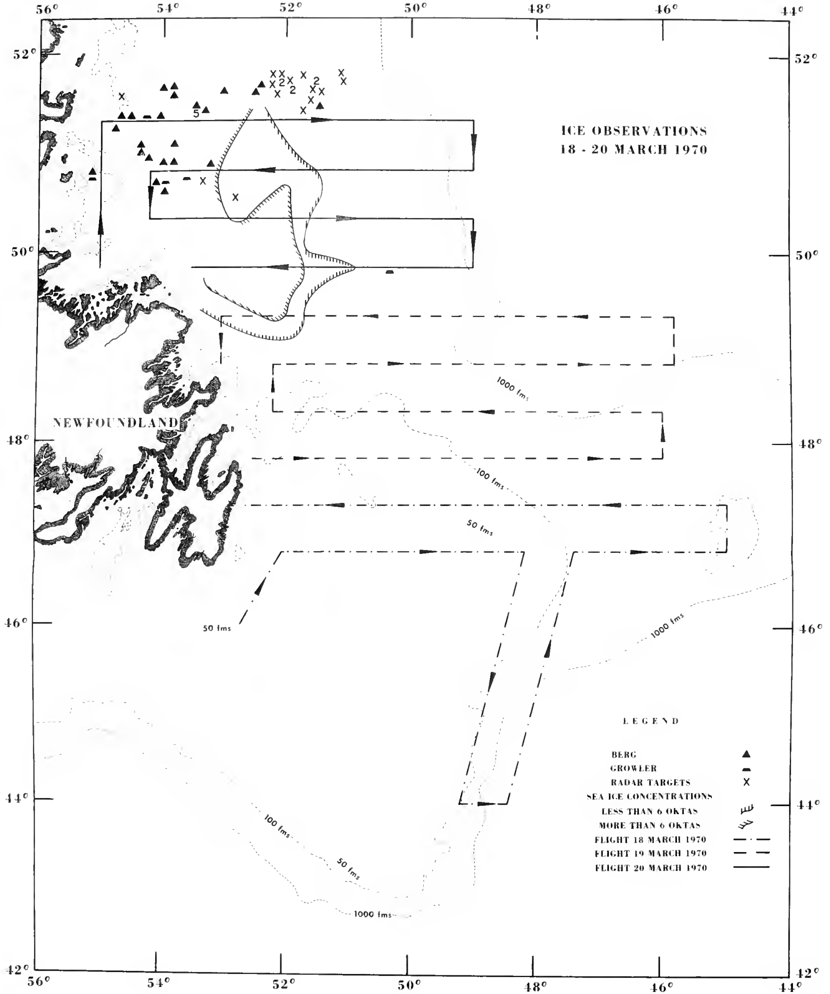

Figure 5 —Ice Observatians, 18-20 March 1970.

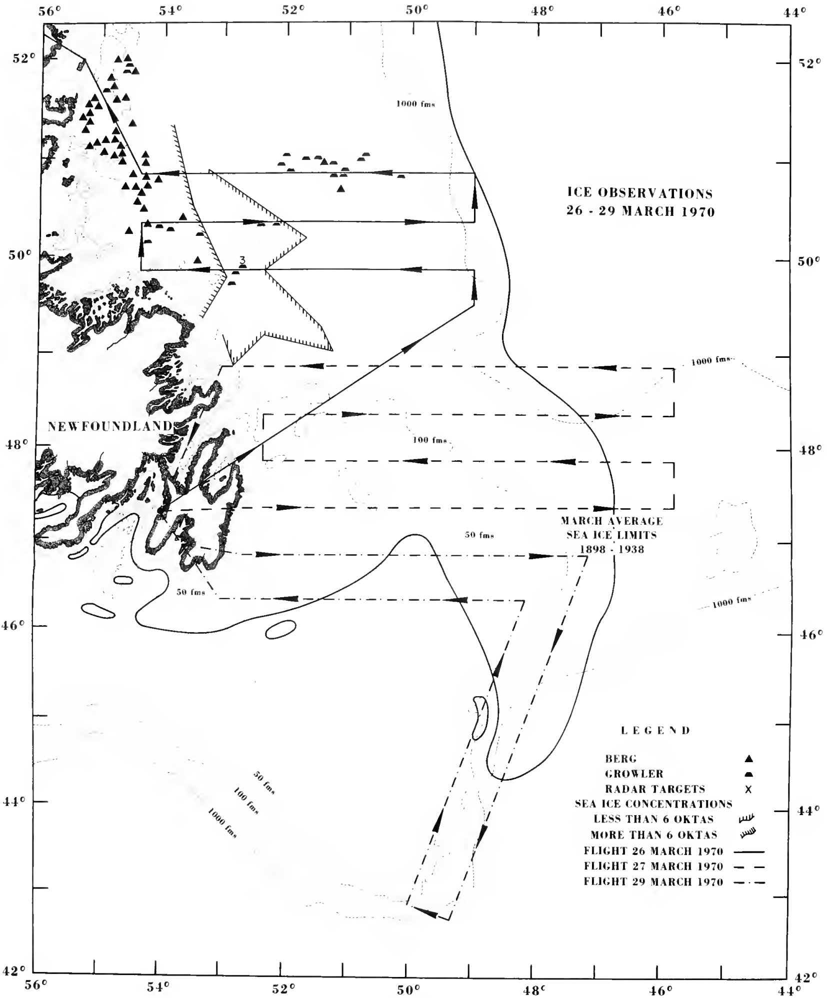

Figure 6.—Ice Observations, 26-29 March 1970.

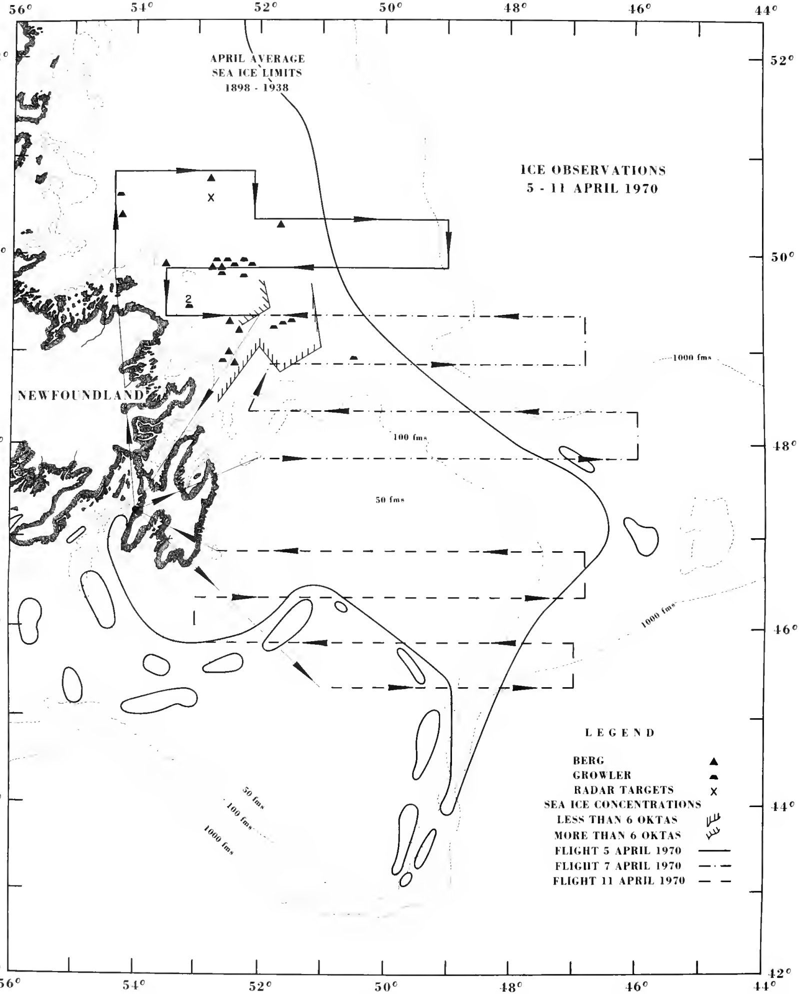

Figure 7.—Ice Observations, 5-11 April 1970.

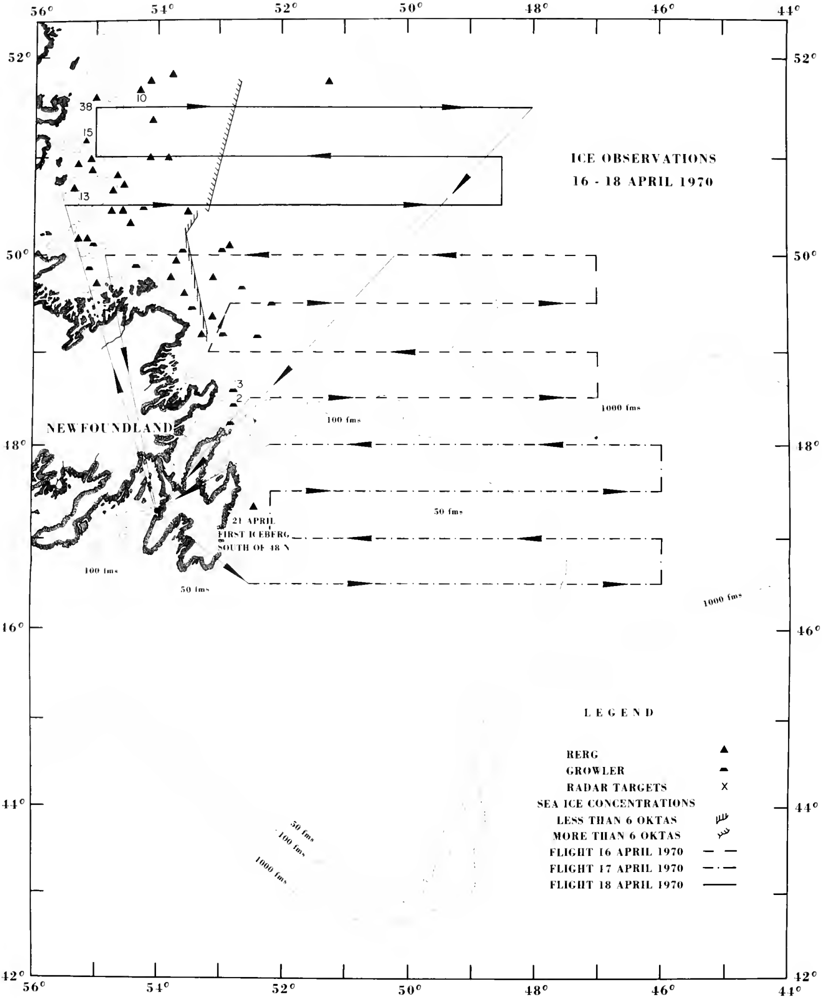

Figure 8.—Ice Observations, 16-18 April 1970.

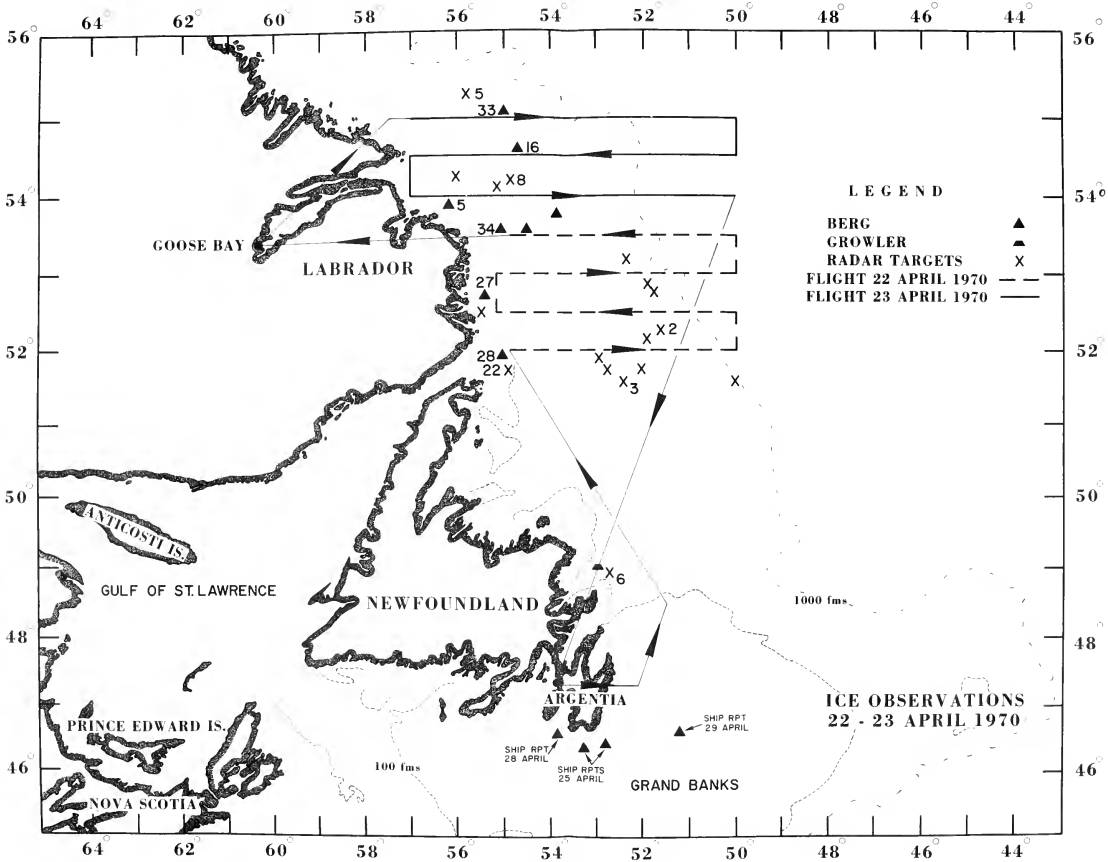

Figure 9.—Ice Conditions, 22-23 April 1970.

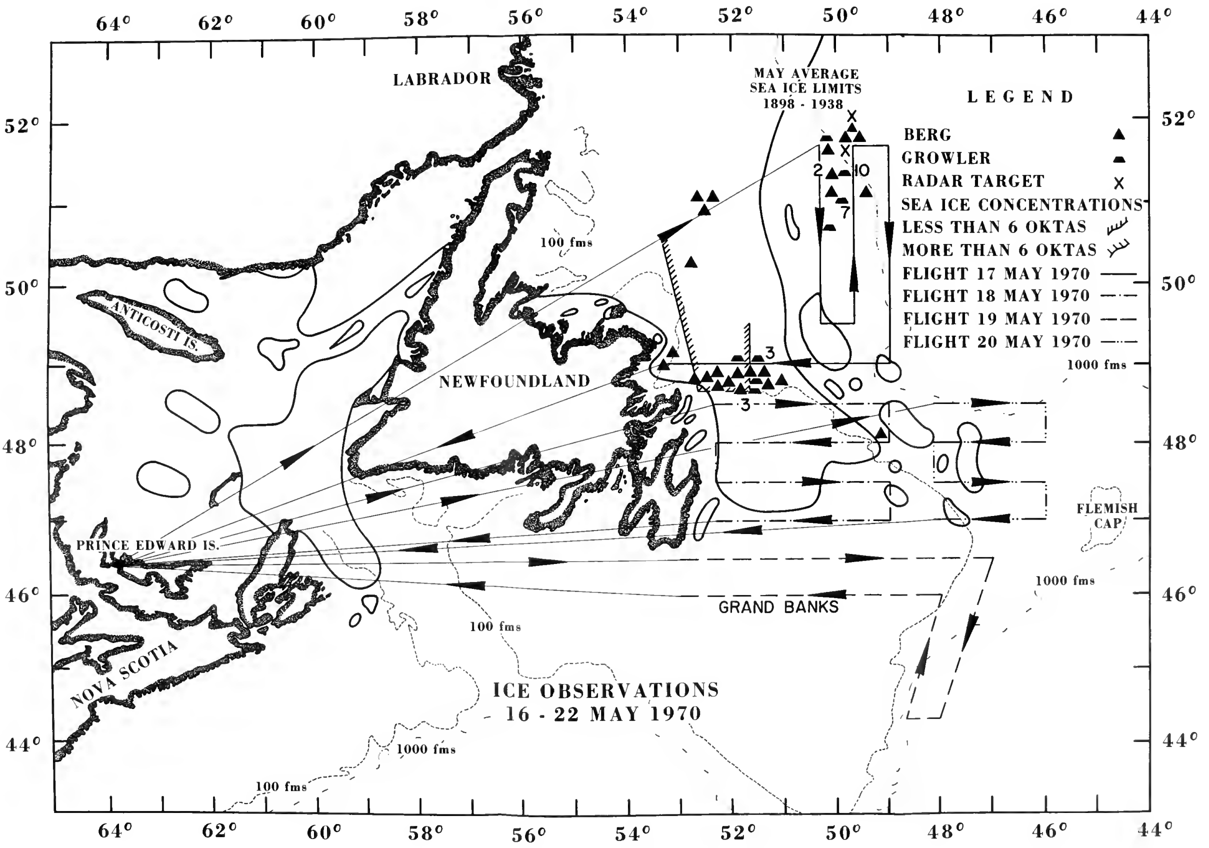

Figure 10.—Ice Observations, 16-22 May 1970.

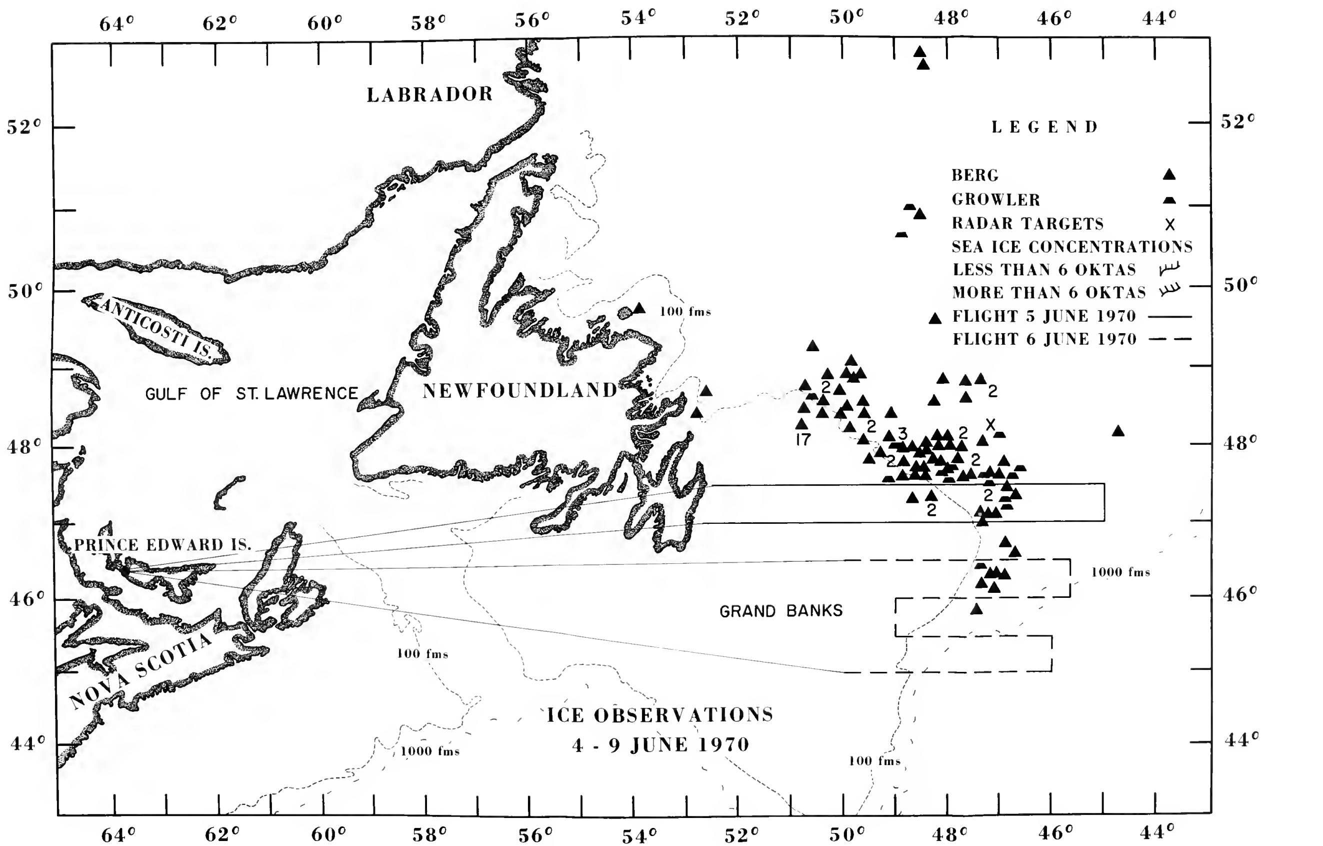

Figure 11.—Ice Observations, 4-9 June 1970.

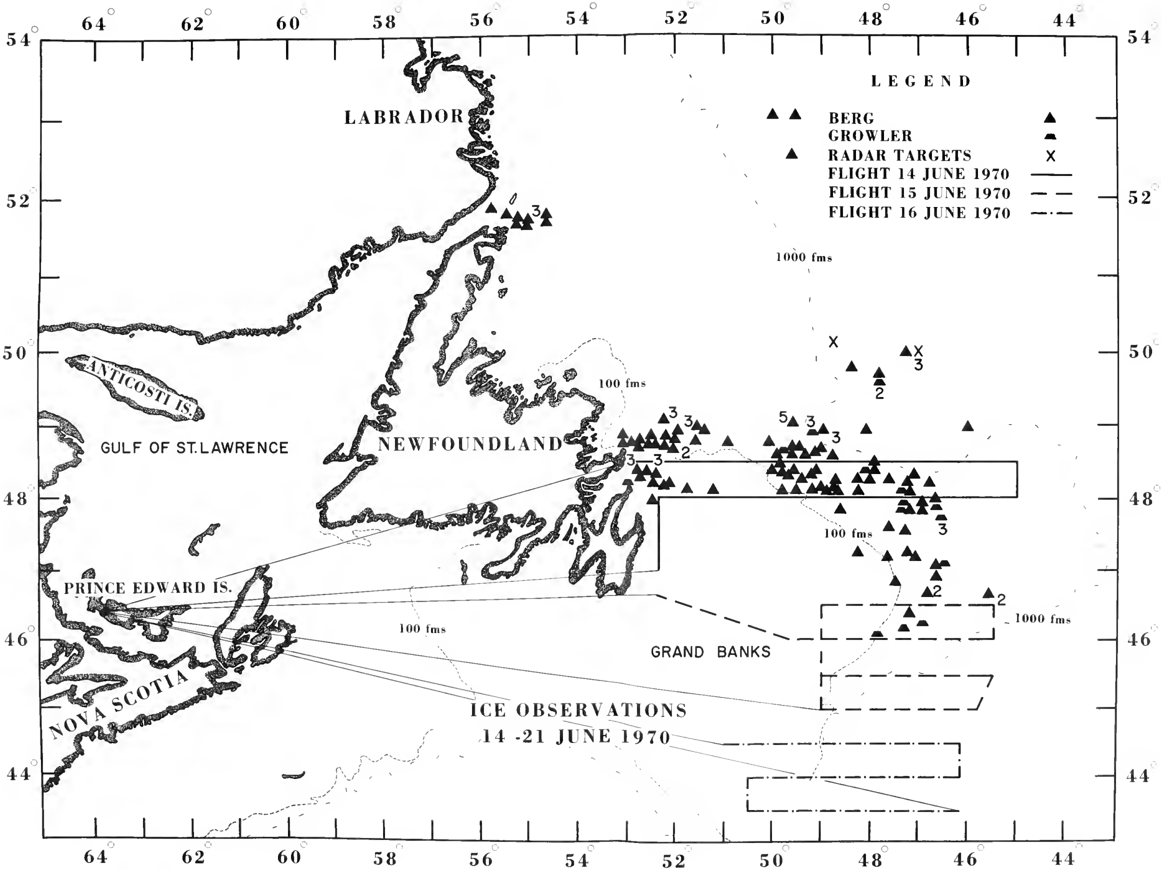

Figure 12.—Ice Observations, 14-21 June 1970.

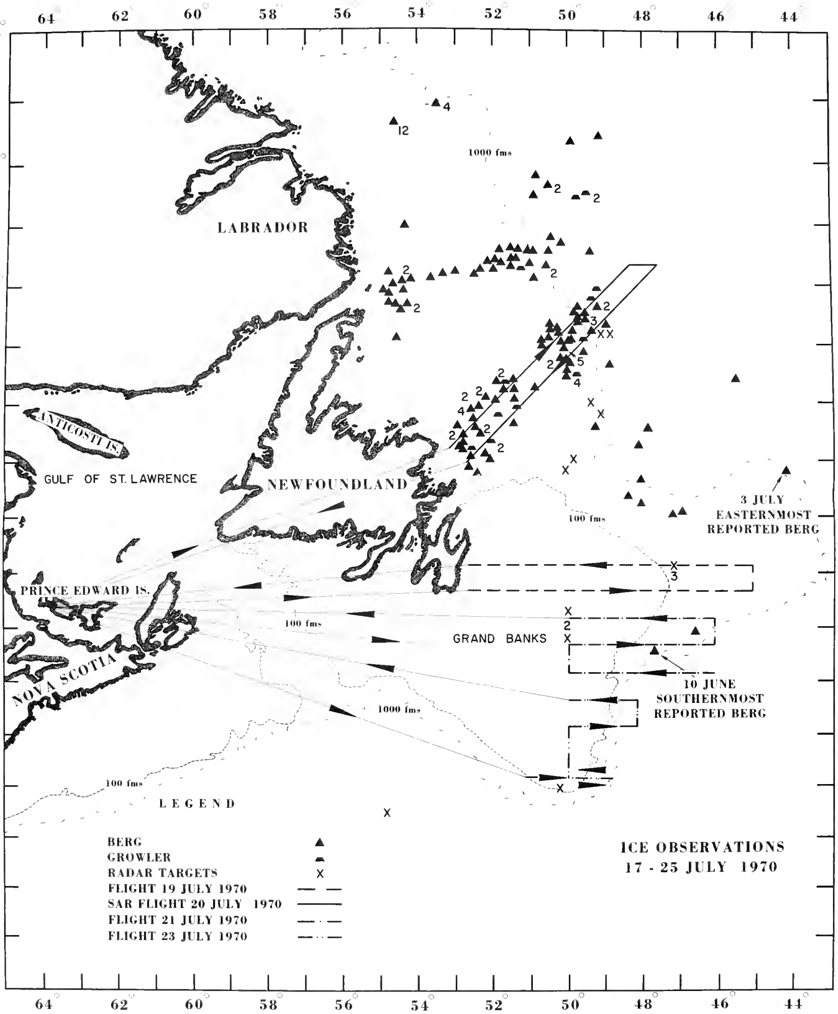

Figure 13.—Ice Conditions, 17-25 July 1970.

OCEANOGRAPHIC CONDITIONS, 1970

(Provided by U.S. Coast Guard Oceanographic Unit)

Two oceanographic cruises were conducted during the Ice Patrol season aboard USCGC *Evergreen* (WAGO 295). The dynamic topography of the sea surface relative to the 1000 decibar surface was obtained from these cruises (figures 14–17). The most prominent feature of the circulation was the Labrador Current flowing southward along the eastern slope of the Grand Banks. Farther east was the dynamic trough that separates the Labrador Current from the northwestward flowing North Atlantic Current.

Conditions found during the 1970 season differed somewhat from the normal or average conditions. There was evidence of an additional dynamic low in the vicinity of 44N, 47W (figures 15 and 16). This low was caused by an unusual clockwise dynamic high to the north at 45N, 47W (figures 16 and 17). The features of this high could be observed at least as deep as 1200 meters. The Labrador Current had a particularly intense geostrophic current (2.5 knots) on 31 May–1 June at 44–30N 48–50W. This occurred because the sea surface in the trough fell 10 dynamic centimeters during the preceding 6 days.

A detailed survey off the southeast slope of the Grand Banks was made to determine the circulation over the Newfoundland Rise. The charts of normal dynamic topography do not adequately define the circulation of this region because of its high variability. The circulation indicated by the mass distribution was much more complicated than expected (figure 16). There was a great deal of difference observed in the circulation by two oceanographic surveys of roughly the same area (figures 15 and 16). These differences may result from two factors. First, the circulation may have changed during the interval between the two surveys. Second, the section spacing was greater on the first cruise than on the second, thus much of the detail may have been lost on the first cruise.

A more detailed analysis of the oceanography of the Grand Banks and the Labrador Sea in 1970 will be published in the U.S. Coast Guard Oceanographic Report Series (CG–373).

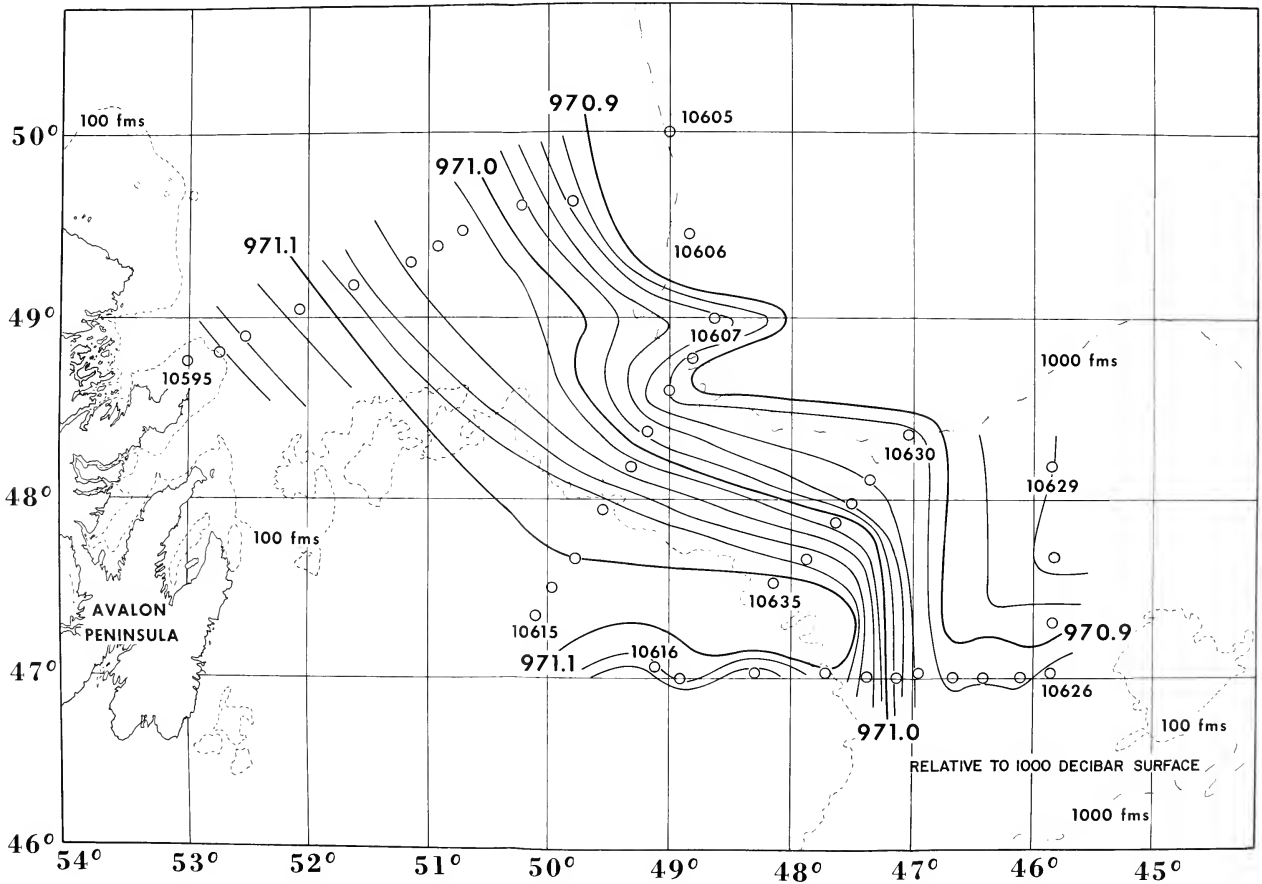

Figure 14.—Dynamic Topography of the Sea Surface With Reference to the 1000 Decibar Surface. First Cruise, First Segment (7 to 10 April 1970).

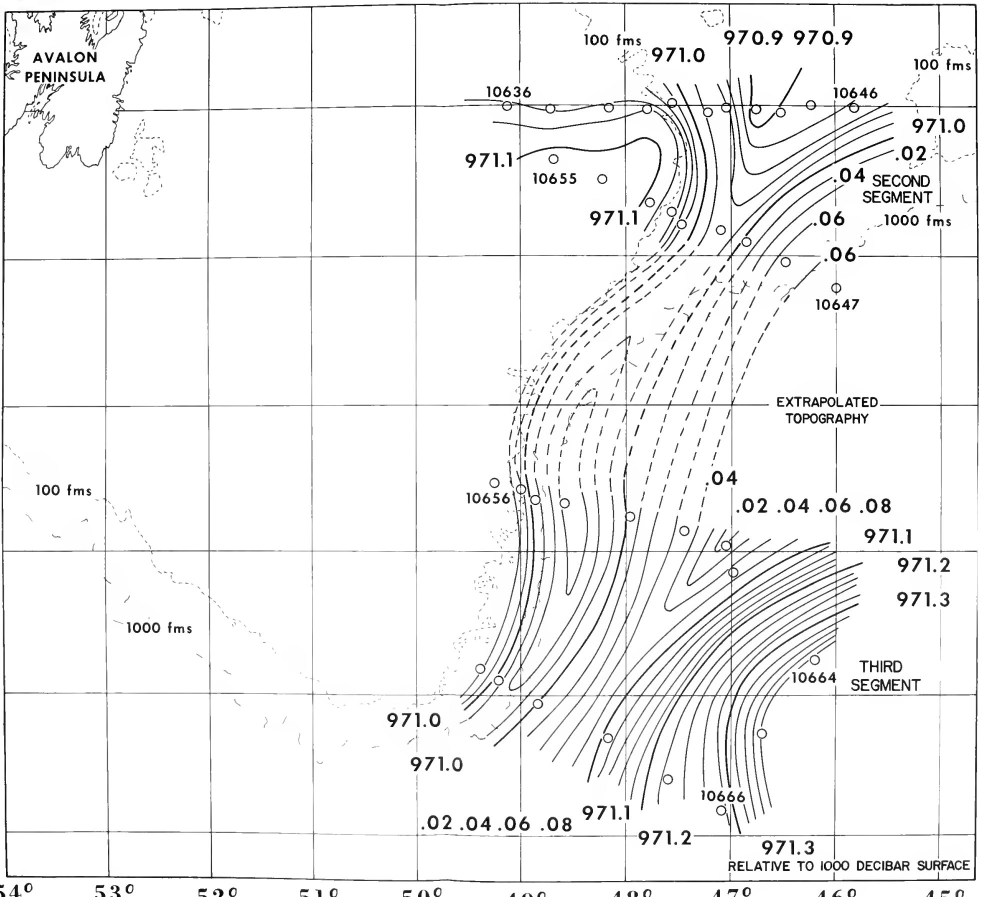

Figure 15.—Dynamic Topography of the Sea Surface With Reference to the 1000 Decibar Surface. First Cruise, Second Segment (15 to 17 April 1970) and Third Segment (21 to 24 April 1970).

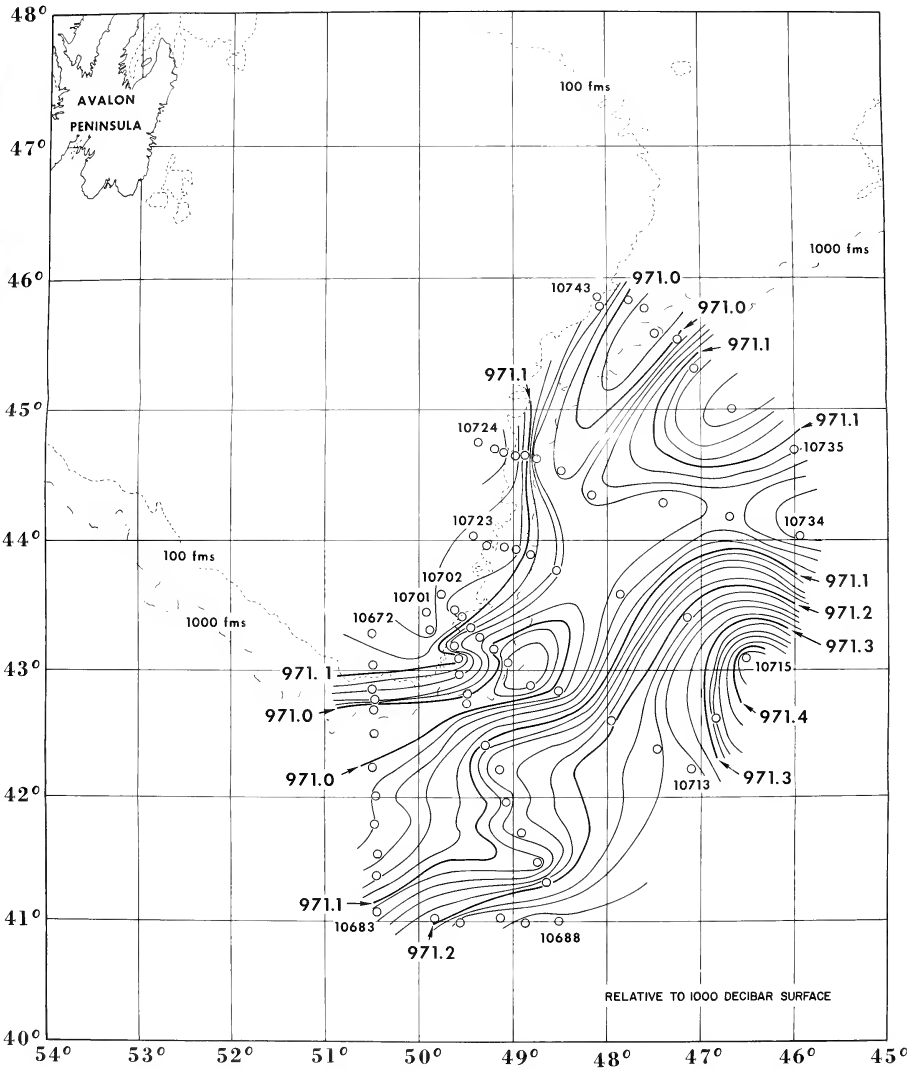

Figure 16.—Dynamic Topography of the Sea Surface With Reference to the 1000 Decibar Surface. Second Cruise, First Segment (17 to 25 May 1970).

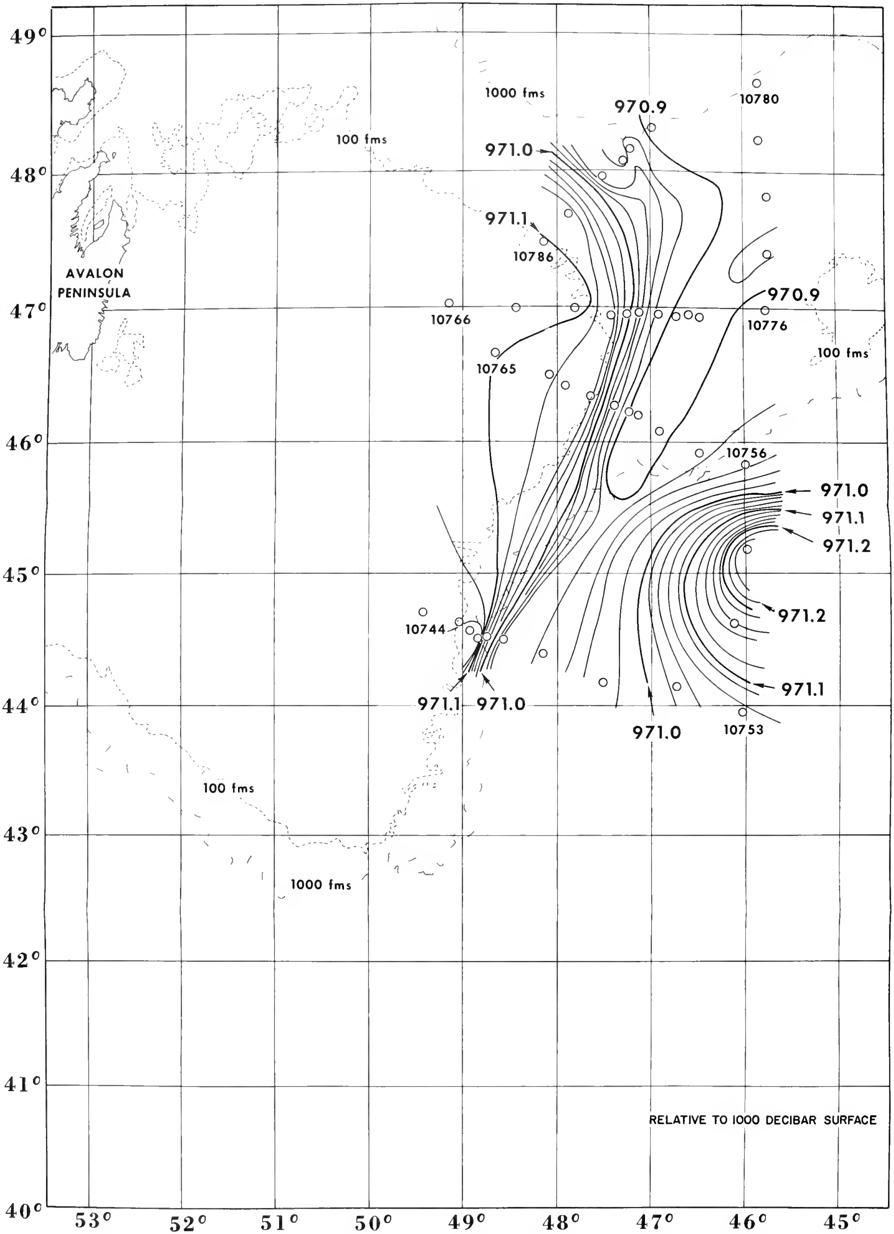

Figure 17.—Dynamic Topography of the Sea Surface With Reference to the 1000 Decibar Surface, Second Cruise, Second Segment (29 May to 2 June 1970).

DISCUSSION OF ICEBERG AND ENVIRONMENTAL CONDITIONS DURING 1970 SEASON

The question of how and why the iceberg season develops as it does is always of interest to the Ice Patrol. This is particularly true when the season does not develop as expected, as happened in 1970. The three major factors which influence the development of the season are (1) the number of icebergs available to drift onto the Grand Banks, (2) the strength of the northwesterly winds which transport the icebergs south, and (3) the rate of deterioration the icebergs experience due to melting and wave action. In early March, as described in the section on ice conditions, there were 95% more icebergs present north of Hamilton Inlet than normal. Therefore the potential for a heavy iceberg season was present, and it was the factors which influence iceberg drift and deterioration which led to a light season.

The features of the Labrador Current, as described in figures 14–17, appear sufficiently well developed to play their usual role in transporting icebergs along the eastern slopes of the Grand Banks. The recurvature of isotachs at about 45N to 46N on all four surveys indicates that some icebergs in the Labrador Current would be unable to drift south of about 45N or 46N. In fact the southernmost iceberg of the season was located at about 45–35N in the southern part of the eddy indicated by the 970.9 dynamic meter isotach on figure 17. At the end of the second cruise there does not appear to be any significant eastward branching of the Labrador Current between the northeast slope of the Grand Banks and Flemish Cap; however this could occur later.

Sea surface temperatures on the northeast slopes of the Grand Banks, as revealed by comparison of sea surface temperature charts from Fleet Weather Central Norfolk with normal sea surface charts given in Report of the International Ice Patrol in the North Atlantic, Season of 1964, appeared to be about a degree Fahrenheit or more warmer than average from late April through at least early June. This probably had some effect in hastening the melting of icebergs.

Figures 18a through 18d show the normal and the 1969/1970 surface atmospheric pressure patterns for November through June. Pressure patterns through January do not appear as if they would impede the southward drift of icebergs to any unusually great degree. This, in connection with the above normal iceberg counts noted in December and in the fall, probably accounts for the higher than average iceberg count along the Labrador coast in February. In March there is a splitting of the Icelandic low, with a secondary low forming over Newfoundland. The average cyclonic circulation associated with this low would have been unfavorable to any strong eastward drift of icebergs from the area of Belle Isle Strait or north. The average pressure pattern for April shows that the secondary low still exists, however it is now centered slightly to the east of Newfoundland. In this position winds would continue to be generally unfavorable for the drift of icebergs along the eastern slopes of the Grand Banks, however the winds would not generally oppose the drift of icebergs along the Avalon Peninsula. In fact the five icebergs that did drift south of 48N in April all did so to the west of 50° west longitude. During May the secondary low near Newfoundland disappeared and a fairly intense Icelandic low was established. This resulted in winds with a westerly component predominating in the coastal areas of Newfoundland and southern Labrador. These average westerly winds continued through June.

As a more quantitative indicator of the wind, one may examine the difference in atmospheric pressure along a line as a measure of the average wind perpendicular to the line. Four such lines are labeled gradients 1 through 4 in figure 19. Gradients 1 and 2 measure the winds which are important in transporting icebergs to the general area of the waters off northeast Newfoundland. Gradient 3 is a measure of the winds which assist

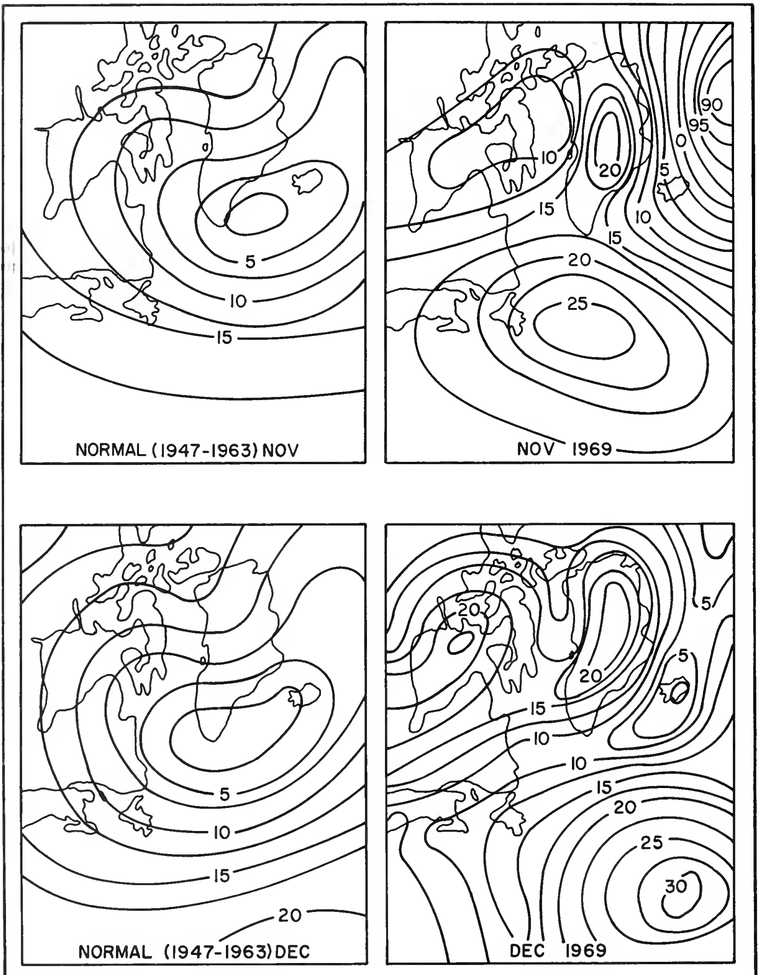

Figure 18a.—November and December Normal and 1969 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

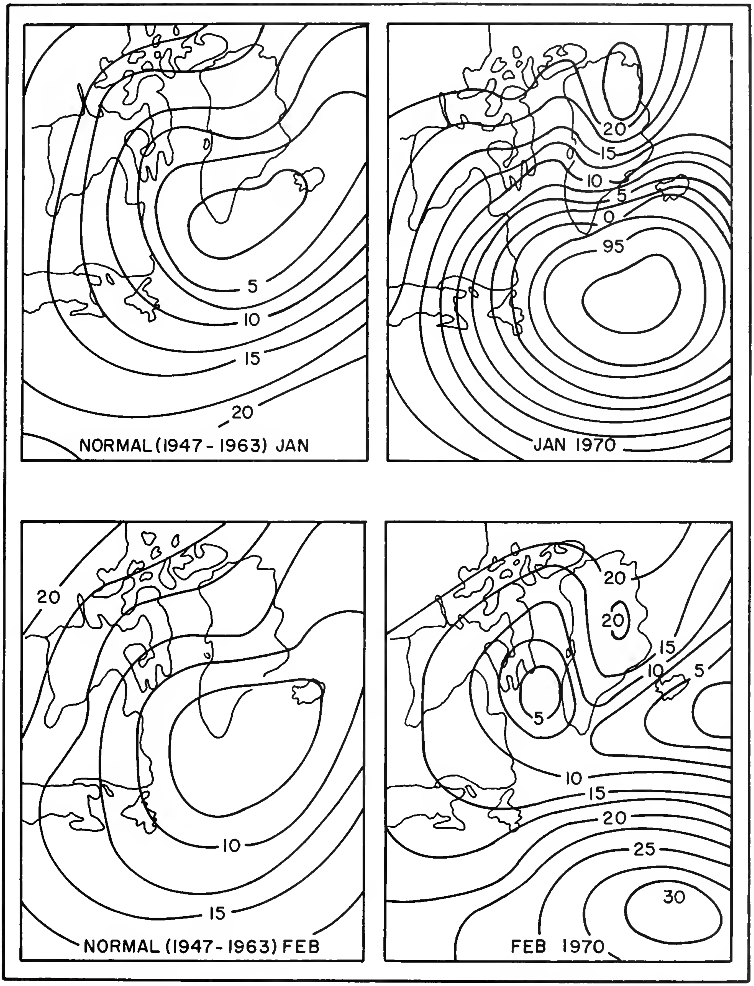

Figure 18b.—January and February and 1970 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

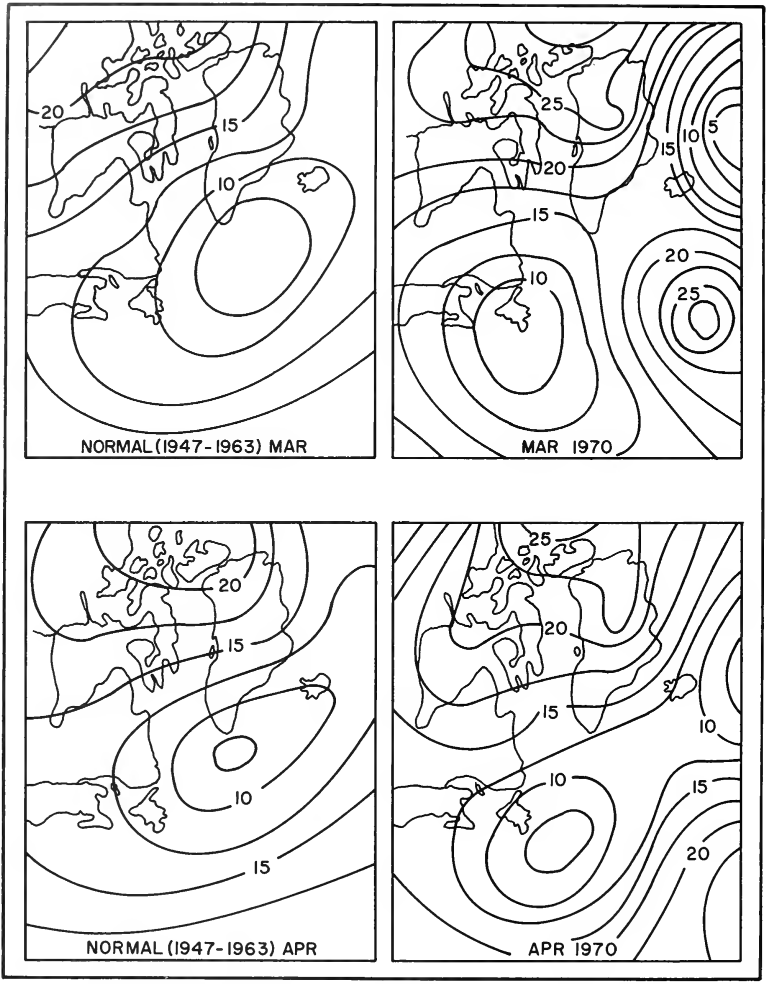

Figure 18c.—March and April Normal and 1970 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

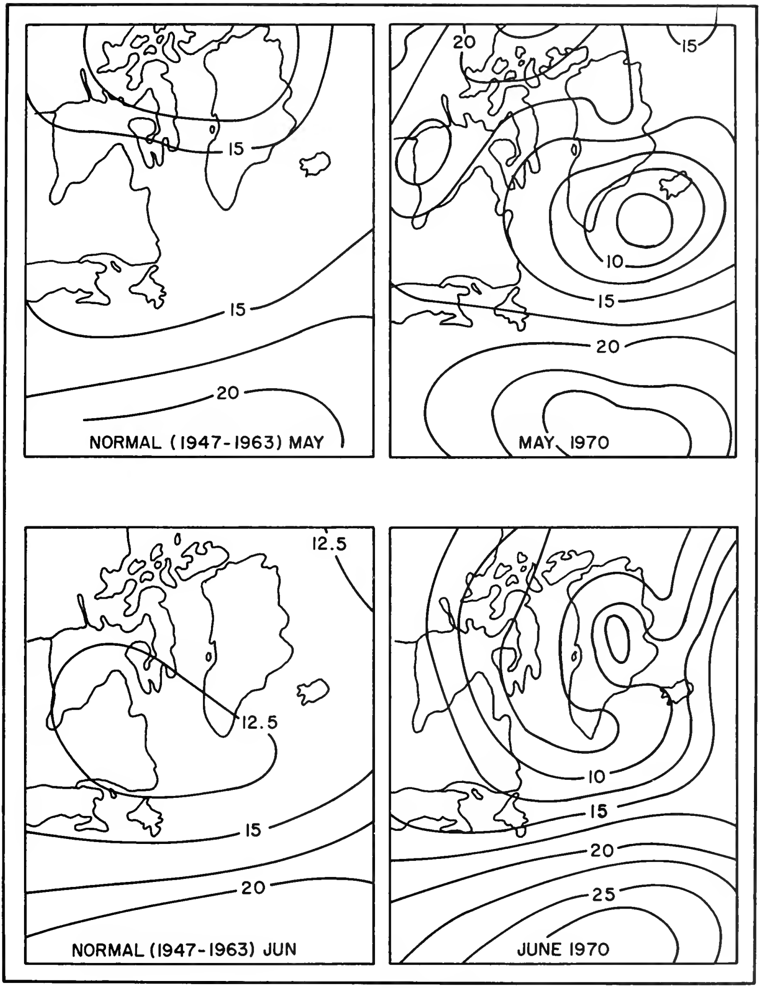

Figure 18d.—May and June Normal and 1970 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

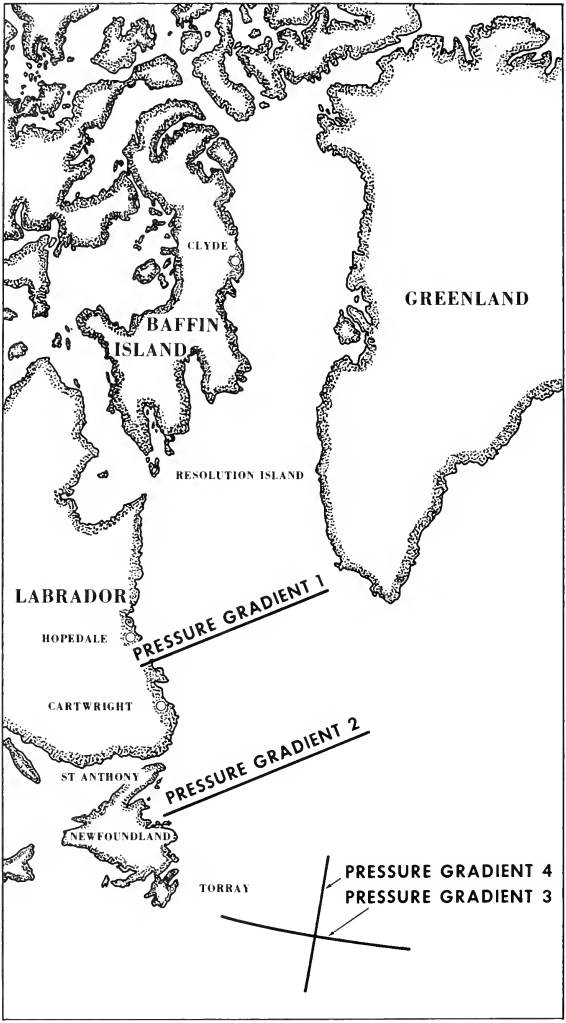

Figure 19.—Lacator Chart.

or impede icebergs as they drift along the eastern slopes of the Grand Banks. Gradient 4 is a measure of the strength of generally westerly winds along the north slopes of the Grand Banks. These winds are often important in carrying icebergs away from the northeast Newfoundland coast and out into the Labrador Current. However, if they are too strong when icebergs reach the northeast corner of the Grand Banks where the Labrador Current turns south, then the icebergs may be carried eastward out of Labrador Current and into warmer waters which drift generally northeastward.

Gradients 1 and 2 (see figure 20) indicate winds more unfavorable for the southward drift of ice than normal in March and early April, and more favorable than normal in later April, May, and June. This appears to have had the effect of initially limiting the supply of icebergs to the northern Grand Banks. The fact that there were only two icebergs south of 48N in May be attributed to the time required for icebergs to drift

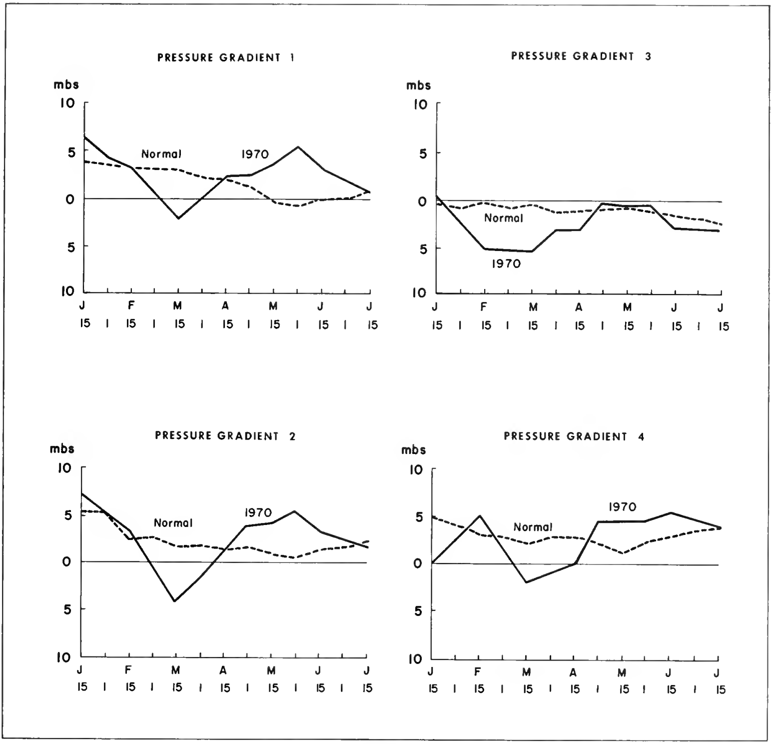

Figure 20.—Pressure Gradients 1-4.

south to 48N after winds became favorable in later April. Gradient 3 shows that winds were generally unfavorable for iceberg drift along the eastern slopes of the Grand Banks until early May when conditions became neutral and remained so through early June when they again became unfavorable. Pressure gradient 4 shows that winds would have tended to hold icebergs in along the Newfoundland coast until early May. As the iceberg supply on the northern Grand Banks became adequate in early June there appears to have been a tendency for winds, as measured on gradient 4, to carry them eastward out of the Labrador Current.

Winter and spring air temperatures along the Baffin Island, Labrador and Newfoundland coasts were generally warmer than normal, as can be seen in figure 21. The locations of the stations given on figure 21 are shown on figure 19. A frost degree-day, as used in figure 21, is defined as one day at a temperature of one fahrenheit degree below 32°. Thus one day at 20°F would be 12 frost degree-days. Similarly a melting degree-day is defined as a day at a temperature of one Fahrenheit degree above 32°. Actually figure 21 was calculated on the basis of the average monthly temperature and multiplied by the number of days in the month rather than on the basis of the average daily temperature for each day.

The only station which was not below normal in frost degree-day accumulations was Resolution Island. Along the Labrador and Newfoundland coasts it appears that the reason for the low frost degree-day accumulations was a late winter. Once temperatures dropped below freezing monthly frost degree-days were usually only slightly lower than normal. An exception to this was St. Johns where the frost degree-days in February and March were much below normal. The effect of these below normal frost degree-days would be to inhibit the formation of sea ice, which in turn would hasten the deterioration of icebergs since sea ice generally serves to protect icebergs from the eroding influence of wave action. The below normal extent of sea ice has already been mentioned in the section on ice conditions during 1970.

Melting degree-days at St. Johns in May and June were above normal. This would tend to cause increased melting of icebergs in the area.

To summarize, it appears that in spite of a large supply of icebergs, a heavy 1970 iceberg season failed to materialize because wind, air temperature, sea surface temperature, and sea ice conditions were not favorable for the transport of icebergs south of 48°N.

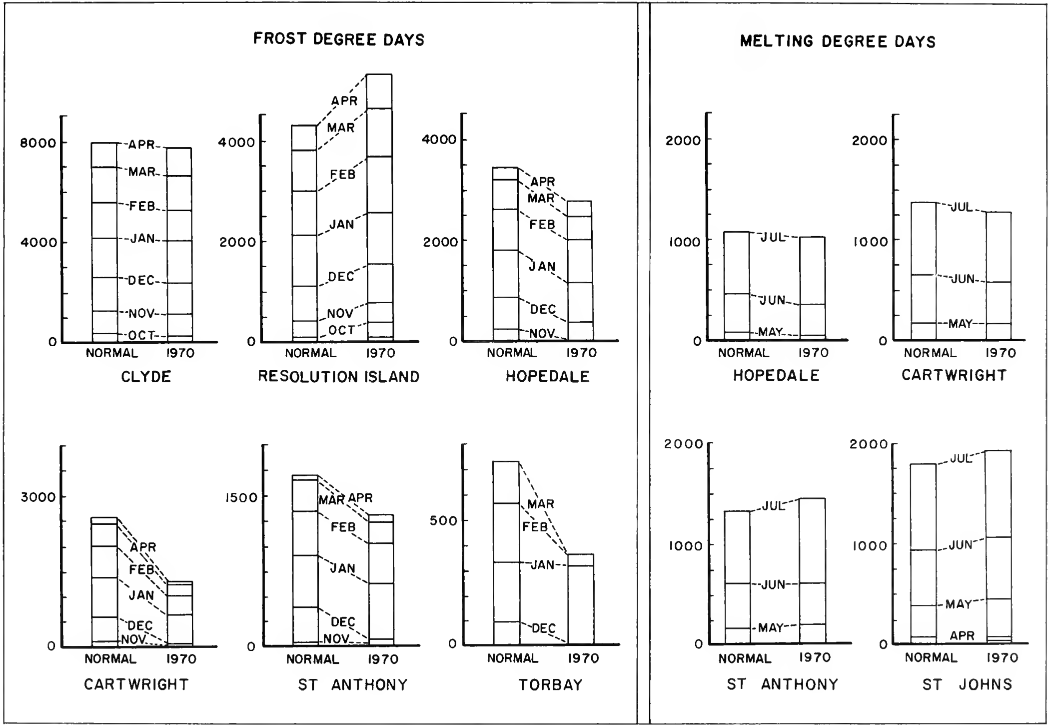

Figure 21.—Frost Degree Day and Melting Degree Day Accumulations Calculated From Monthly Mean Fahrenheit Air Temperature.

ICEBERG DISTRIBUTION IN BAFFIN BAY AND THE LABRADOR SEA AS DETERMINED FROM PRESEASON ICE PATROL FLIGHTS BY THE UNITED STATES COAST GUARD

By C. W. Morgan, U.S. Coast Guard

Abstract

The purpose and background of preseason Ice Patrol flights by the U.S. Coast Guard is discussed. The technique of preseason aerial iceberg reconnaissance is described. The results of the flights are analyzed in terms of average and observed icebergs per two square degrees for Baffin Bay in summer and fall, for southwestern Baffin Bay and the Labrador coast in early December and January, and for the Labrador coast in February. Deviations from the average are analyzed for the fall Baffin Bay data.

Data from the preseason flights show that patterns of iceberg concentration are generally the same from year to year, although there are usually changes in the overall level of concentration. Patterns of iceberg concentration in Baffin Bay indicate that the movement of icebergs directly across Baffin Bay may be as important as the route north through Melville Bay. Analysis of the dissipation of a large positive iceberg anomaly off Cape York during the period 1966–69 indicates that it takes about 3 years for a heavy accumulation of icebergs in northern Baffin Bay to clear out. Analysis of the February data indicates that there is a fair positive correlation (0.61) between iceberg concentrations observed on the February flight and the severity of the iceberg season on the Grand Banks. There is also fair positive correlation (0.77) between the southernmost extent of icebergs observed on the February flight and the date when icebergs arrive on the Grand Banks.

Introduction

The icebergs which drift south in the spring of each year to threaten shipping in the area of the Grand Banks of Newfoundland come mostly from the glaciers which terminate in Baffin Bay. The questions of exactly how icebergs drift from their source glaciers to the Grand Banks, how long it takes, and how icebergs are distributed in Baffin Bay and along the Labrador coast have been of interest to the U.S. Coast Guard in managing the International Ice Patrol and to others, for many years.

The interest of the U.S. Coast Guard concerning icebergs in Baffin Bay and along the Labrador coast grew from a desire to understand better the entire iceberg problem. Following the R.M.S. *Titanic* disaster of 1912 the Coast Guard was assigned the duty of operating the Ice Patrol. It was readily apparent that an understanding of the natural factors controlling the drift and deterioration of icebergs would be of great value in intelligently operating the patrol. Information on iceberg distributions in Baffin Bay and along the Labrador coast is an important part of understanding the total iceberg problem. It has long been suspected that the number and distribution of icebergs available to drift south from Baffin Bay could be a significant factor in determining the severity of iceberg conditions on the Grand Banks during a given ice season.

The first attempt to collect information systematically on iceberg distributions north of the Grand Banks was in the summer of 1914 when the U.S. Revenue Cutter *Seneca* sailed as far north as southern Labrador "to observe the origin of the ice which annually appears on the Banks of Newfoundland, and to investigate the agencies by which it is transported from the North." (Johnson, 1915). The next expedition took place 14 years later when the U.S. Coast Guard Cutter *Marion* was dispatched as far north as Disko Island for oceanography and ice observation under the command of Lieutenant Commander (later Rear Admiral) Edward H. "Iceberg" Smith (Smith, 1931). Later cruises and expeditions were made by the ships indicated below.

1931	USCGC *General Greene*	Southern Greenland and Labrador coast to Hudson Strait.
1933	USCGC *General Greene*	Southern Greenland and Labrador coast to Hudson Strait.
1934	USCGC *General Greene*	Southern Greenland and Labrador coast to 54N.
1935	USCGC *General Greene*	Southern Greenland and Labrador coast to 54N.
1936	USCGC *General Greene*	Southern Greenland and Labrador coast to 54N.
1938	USCGC *General Greene*	North to Davis Strait.
1939	USCGC *General Greene*	Southern Greenland and Labrador coast to 54N.
1940	USCGC *Northland*	Baffin Bay.

The cruise of the *Northland* in September of 1940 was the first attempt at a complete survey of the icebergs in Baffin Bay. The results of the iceberg surveys conducted by the *Marion* in 1928 and the *Northland* in 1940 are shown in figure 22. The cruises by these two ships were important because they provided the first systematic information about iceberg conditions in the Labrador Sea and Baffin Bay. Although these two efforts at surveying were necessarily limited by the speed and visibility from the ships, the results established iceberg distribution patterns which have been affirmed by later aerial surveys.

The cruise of the *Northland* was the last use of a ship for the purpose of trying to survey large areas of Baffin Bay or the Labrador coast for icebergs. The cruise of the *Northland* had actually been the first of a series of three annual summer cruises recommended in December 1939. The Second World War resulted in the discontinuation of the series. Following the war, in July 1948, a Coast Guard PB1G Flying Fortress patrol aircraft made the first aerial iceberg survey of Baffin Bay. The aircraft was equipped with an aerial camera, and many of the glaciers and fjords of western Greenland were photographed. The following year, in August 1949, a second survey was made, this time utilizing two PB1G aircraft. Over 1800 aerial photogrpahs were taken on the second survey and used in determining the number of icebergs present along the west coast of Greenland. In accordance with the recommendations of 1939 a third survey was planned to complete the series in 1950. Unfortunately the partial closing of one of the airfields from which the surveys were conducted led to the abandonment of the 1950 survey. Although interest remained in the northern iceberg surveys, 14 years were to pass before they recommenced. However preseason iceberg reconnaissance flights to guard against an unexpected intrusion of icebergs onto the Grand Banks were routinely made as far north as Belle Isle Strait during this period.

In November 1961 and November 1962 the Canadian Department of Transport collected data on iceberg distribution in the course of sea ice surveys in Baffin Bay. The data was provided by the International Ice Patrol, and it was used in analyzing iceberg conditions on the Grand Banks in 1962 and 1963. The Coast Guard recommenced northern iceberg surveys in January 1963 when a SC–130 Hercules patrol aircraft surveyed as far north as southern Baffin Island. Since then surveys at least as far north as Hudson Strait have been made during the periods shown in figure 23. The results of most of these survey flights are given in the Reports of the International Ice Patrol Service in the North Atlantic Ocean for the years 1963 through 1970 (Corwin *et al*, 1964; Lenczyk, 1965a; Lenczyk, 1965b; Murray, 1969a; Murray, 1969b; Murray, 1969c; Kelly and Morgan, 1970. Lenczyk (Corwin *et al*. 1964; 1965a; 1965b) analyzed the 1963, 1964, and 1965 data for the size distribution and travel times of icebergs along the Baffin Island and Labrador coasts. A notable series of surveys were made in 1965 when flights as far north as Hudson Strait were carried out each month of the year, thus giving some indication of the annual iceberg cycle along the Labrador coast. In September 1968 the first complete survey of Baffin Bay since 1949 was made, the surveys between 1964 and 1967 having covered only the western part of the bay. Also in 1968, during August, the U.S. Coast Guard Oceanographic Unit made a photographic survey of West Greenland glacier fronts between 69N and 79N. Similar aerial surveys of Baffin Bay and photographic surveys of the glacier fronts were conducted in the fall of 1969, and are planned for the fall of 1970. When the 1970 surveys are completed they will accomplish the goal set in 1939 of surveys for 3 consecutive years.

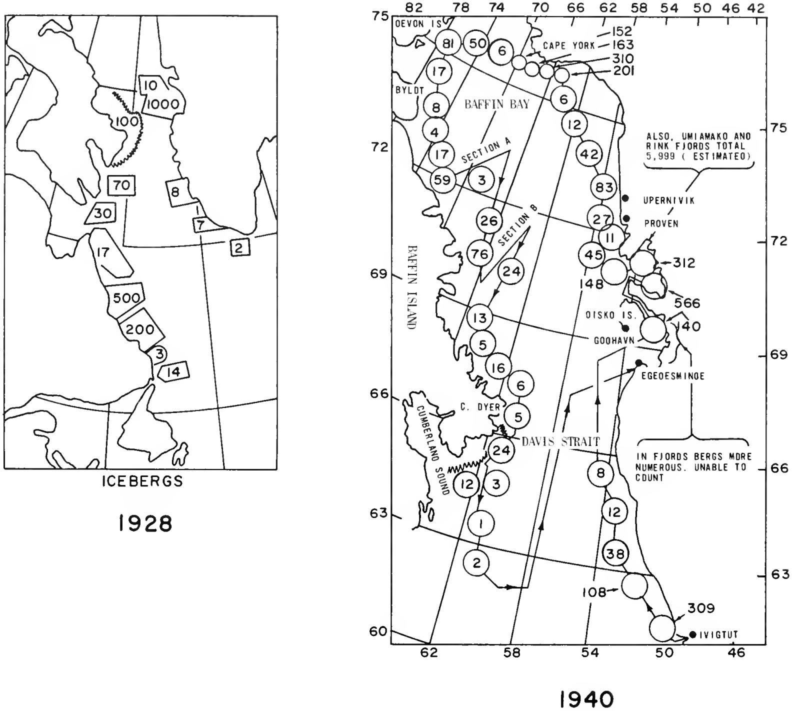

Figure 22.—Distribution of Icebergs as Observed the Summer of 1928 and September 5-23, 1940.

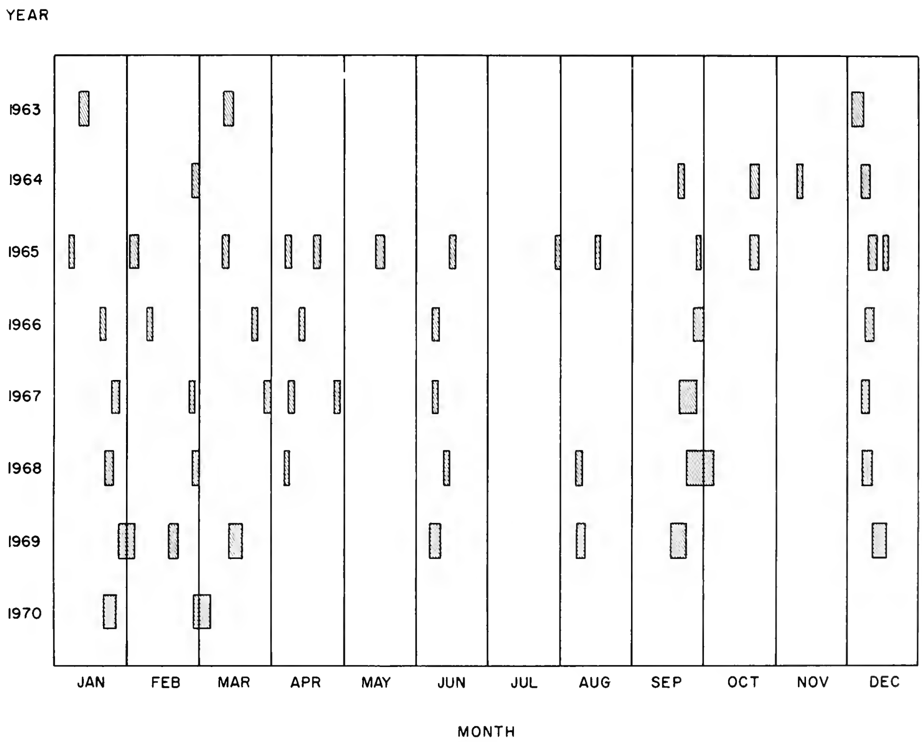

Figure 23.—Monthly Distribution of Northern Icebergs Surveys 1963-70.

Techniques of Preseason Aerial Iceberg Observation

The precise technique used in iceberg observation has varied somewhat from year to year, although generally it is simple and straightforward. In the HC130B Hercules aircraft the ice observers usually sit on stools behind the pilot and copilot where they can see the doppler navigational instruments. One of the ice observers has a chart of the area on a portable plotting board. As the aircraft flies along on its planned tracks, which are normally 25 to 30 miles apart, the ice observers count icebergs as they pass abeam out as far as approximately 15 miles. At the end of a convenient interval, 5 or 10 miles, the number of icebergs counted is plotted on the chart. If the concentration of icebergs is not too large the counts are broken down into small, medium, and large icebergs. Another technique is to record the individual icebergs or groups of icebergs as they pass abeam. In large concentrations this technique requires a third man just to handle the plotting. A third technique is for the observer to pick out mentally an area marked by a few "landmark" icebergs, count the icebergs in that area, record the count in the corresponding area of the chart, and then shift his attention to a new area. In low visibility radar is used to obtain counts by methods identical to those described above for visual use.

On one occasion, in September 1968, a visual statistical sampling technique was used in place of actual counts covering the entire area. This technique was used along the coast and offshore from 30 to 60 miles between latitudes 77–30N and 75–30N because there were too many icebergs to count individually. From comparisons with the 1949 photographic survey it appears to the author that the statistical method is fairly reliable if the following 3 conditions are met: (1) iceberg concentrations are between about 10 and 200 icebergs per hundred square miles, (2) the results are not extrapolated from more than 20 miles off the aircraft track, and (3) the results are not extrapolated to fjords, small bays, or glacier fronts. In using the statistical technique the ice observers made one minute counts of icebergs abeam the aircraft within 7 miles every 3 minutes. The ratio of iceberg concentration beyond 7 miles to that within was also estimated. The miles to go to the next turn point was noted on the doppler navigational readout at the end of each 1 minute count. In the analysis of the data the areas in which counts were made were plotted on a chart, and then the data were interpolated or extrapolated for other areas using the concentration factors.

All of the iceberg surveys since 1963, with the exception of the glacier front surveys, have been visual surveys, supplemented where necessary by radar information. Due to the relative scarcity of shipping in Baffin Bay all radar targets can be presumed to be icebergs. In areas away from the West Greenland coast, probably 90 to 95% of the area of Baffin Bay, visual/radar iceberg observation appears to be adequate for the purpose of determining the general iceberg distribution and approximate count. However, there is a definite psychological tendency for iceberg observers, as they progress northward into Baffin Bay, to disregard an increasing number of smaller size icebergs because they tend to appear as mere growlers or berg bits in the presence of the greater number of very large icebergs found farther north.

The problem of accurate counts within a few miles of the West Greenland coast is much more complicated. Here there are icebergs which may be aground more or less permanently; there are icebergs which may be trapped within a fjord due to a shallow sill; there are icebergs out of sight from Baffin Bay tens of miles up a narrow twisting fjord; there are icebergs so densely concentrated along the front of a glacier that it is impossible to tell from the air where the icebergs stop and the glacier begins; and there are swarms of smaller pieces of ice within the fjords or just outside them which defy consistency in deciding whether they should or should not be included in the count. Visual estimates of the number of icebergs in this area can easily be off by 100% or even more when made from even slow flying aircraft. It is interesting to compare the comments of iceberg observers regarding this area. In a 1949 report it was stated that "Especially in the fjords and along the glacier fronts, the photograph was so full of ice that it staggered the imagination to distinguish bergs from growlers or brash." Using a similar expression a 1968 report notes that "Concentrations of icebergs in some areas in the vicinity of the Greenland coast were so dense that they completely staggered human ability to count the individual icebergs." An iceberg observer once commented orally that

the number of icebergs in the fjords along some glacier fronts will completely "blow your mind." In these areas camera surveys should be used for counts approaching an acceptable accuracy. Even with photographs available the problem of deciding which pieces of ice to count is very difficult in an ice choked area in which there is almost a continuum of pieces of ice covering the spectrum from brash to enormous pieces of glacial ice a mile or more in length. Possibly the best way of evaluating iceberg conditions in the near shore and estuarine area is by the comparison of photographs.

An analysis of the difference between visual and photographic surveys was made of the 1949 data by Soule (1951). Considering the three areas A, B, and C shown in figure 24, Soule found that the ratio between photographic and visual counts for area A was 2.4, for area B was 1.8, and for area C was about 1.0. The high ratio in area A was influenced by the large number of icebergs present in the fjords of West Greenland. The high ratio in area B is probably due to the large number of icebergs which typically congregate between Cape York and Devon Island. The close agreement between photographic and visual counts in area C indicates that visual methods are probably satisfactory for all areas away from the Greenland coast.

Fall Iceberg Surveys

The fall northern iceberg surveys of Baffin Bay include July or August surveys made in 1948 and 1949, and September or October surveys made each year from 1964 to the present. The results of the surveys, in terms of icebergs per two square degrees, are shown in figures 25 through 31. The charts were constructed by plotting the iceberg count for each two square degree areas in the center of the area, and then contouring the resulting chart. The two square degree areas used for plotting were rectangles measuring one degree latitude by two degrees longitude. Thus rectangles were 60 miles in latitude and varied from about 30 to 50 miles in longitude. For features on the contoured chart to be significant they should generally be at least 60 miles in size. Because of the unreliability of nearshore and estuarine counts the contours were not extended into these areas. In general the heavy iceberg concentrations shown off the West Greenland coast appear somewhat farther to seaward than they actually are. This is because the data were plotted in the center of each two square degree area, and the heavy iceberg concentrations usually fall off rapidly away from the coast. The validity of the method of presenting the data may be questioned because of the use of continuous contouring to represent counts of discrete icebergs which are locally random in their distribution. The method appears justified in its results; the contoured distributions are reasonable, and they show a marked similarity from year to year.

Figure 32 is a composite average of all comparable data between 1948 and 1969, and an average of only the September/October data.

The average charts and the charts for the various years show several interesting features which appear to be the normal pattern for summer and fall iceberg distributions in Baffin Bay. It is readily apparent that, with few exceptions, icebergs are concentrated around the periphery of Baffin Bay, with the heaviest concentrations found in eastern Baffin Bay along the Greenland coast. This agrees with Smith's finding (1940) that "bergs were numerous within a coastal zone of 15 miles; farther offshore they became quite scattered to sparse, and farther than 40 miles out they were only occasional. It would appear, from our observations, that in the central portions of Davis Strait and Baffin Bay bergs were very infrequent."

Tongues of icebergs extending westward or southwestward into Baffin Bay from the Greenland coast are commonly found at Disko Bay, Northeast Bay, and between 73N and 75N. If it is inferred that these tongues represent icebergs drifting directly across Baffin Bay, then this path appears to be an important route, in some years possibly more important than the generally accepted route through Melville Bay and then south along Devon, Bylot, and Baffin Island. A comparison of these two routes in 1948, 1949, 1968, and 1969 indicates that each route appears to have contributed approximately the input shown below.

Year	*Percent of input going through Melville Bay*	*Percent of input going directly across Baffin Bay*
1948	64	36
1949	31	69
1968	73	27
1969	55	45

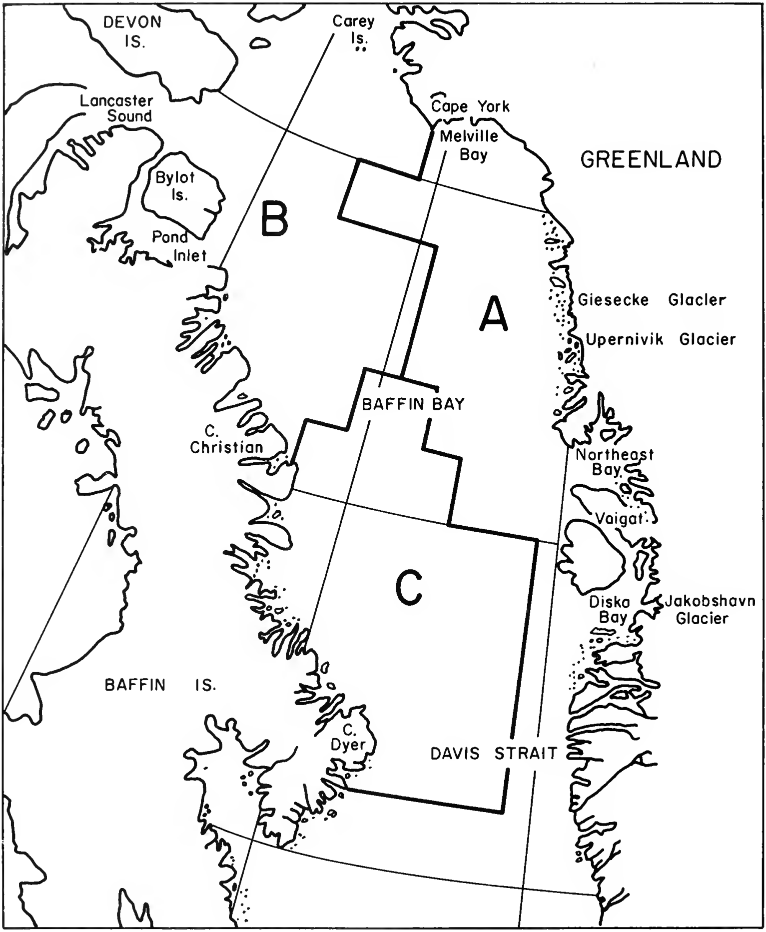

Figure 24.—Locator Chart for Areas A, B, C.

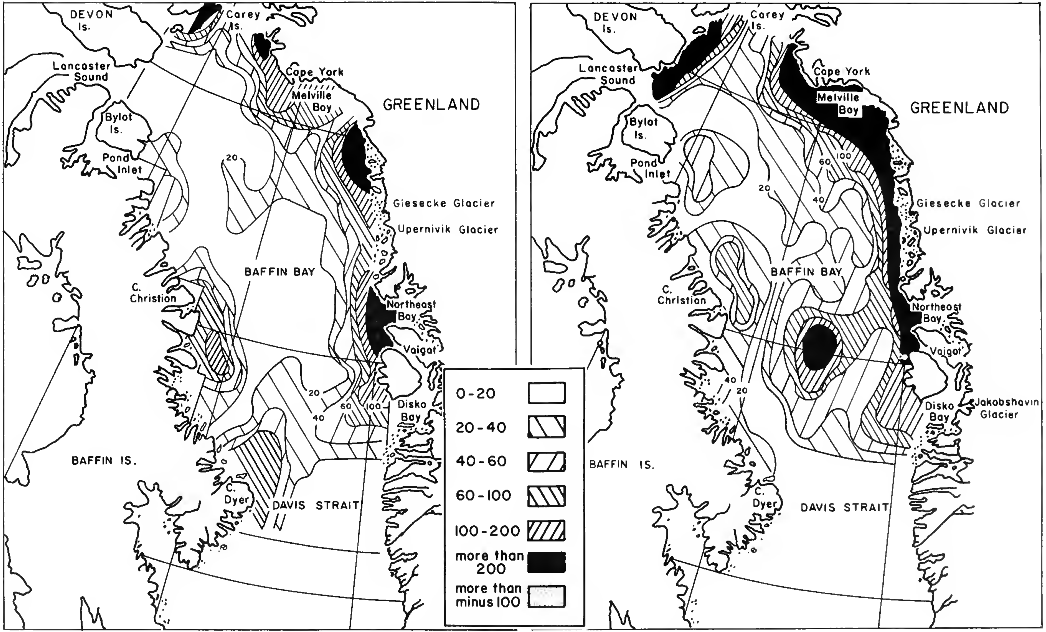

Figure 25.—Iceberg Concentration, 11-30 July 1948 and 10-18 August 1949.

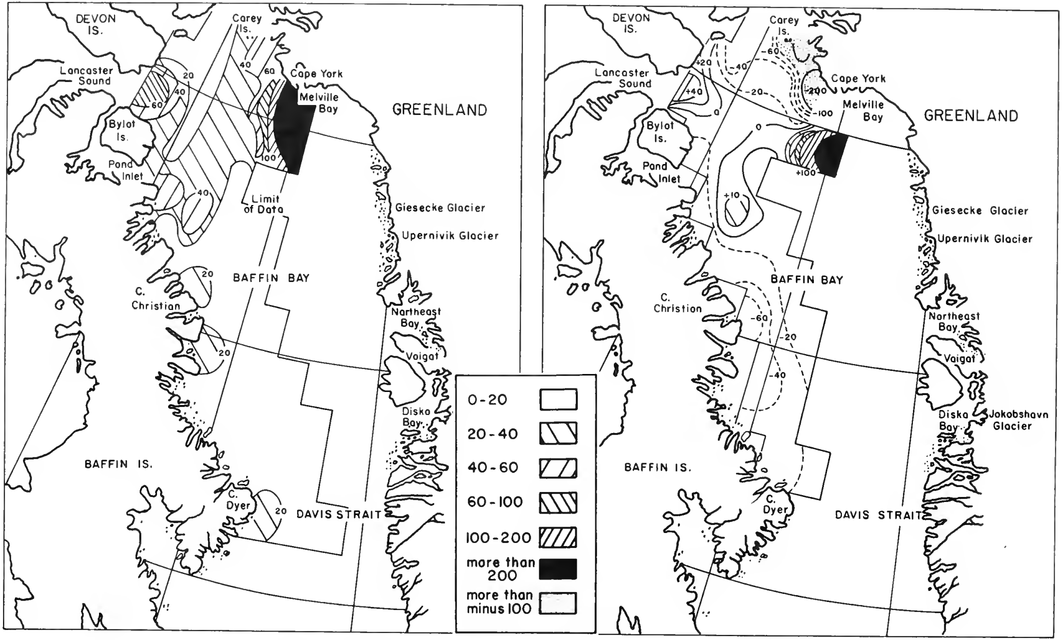

Figure 26.—Iceberg Concentration, 21-23 October 1964, and Anomaly From 1964-69 Average.

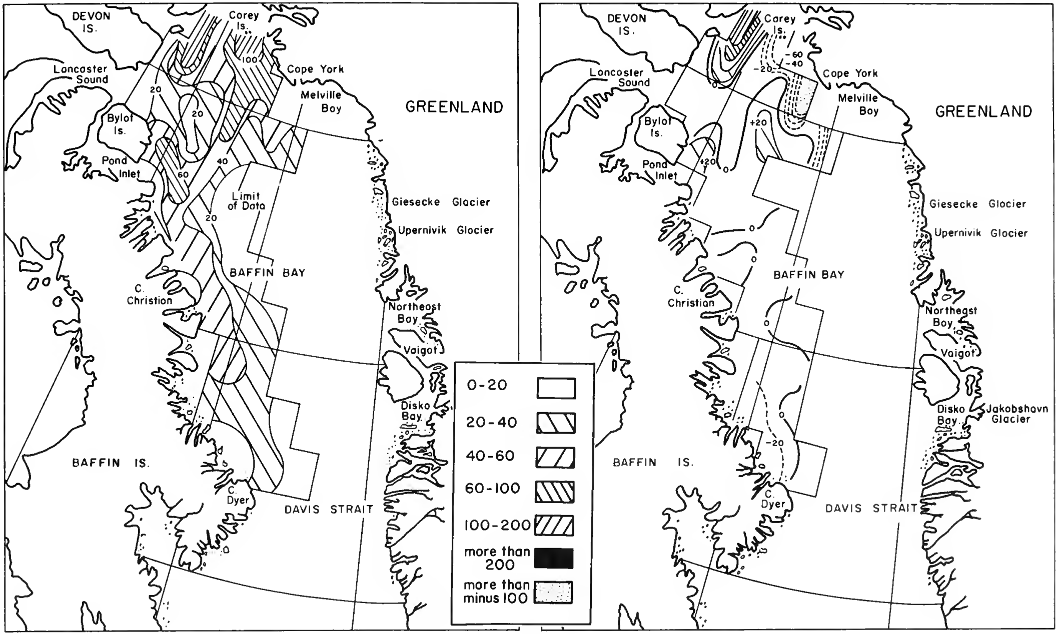

Figure 27.—Iceberg Concentration, 20-22 October 1965, and Anomaly From 1964-69 Average.

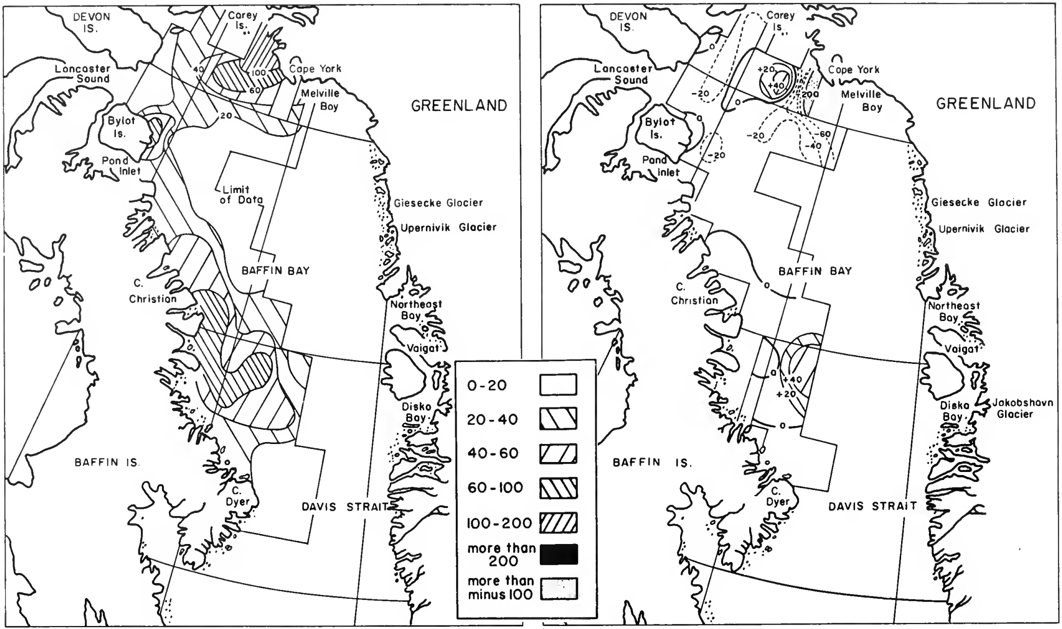

Figure 28.—Iceberg Concentration, 26-30 October 1966, and Anomaly From 1964-69 Average.

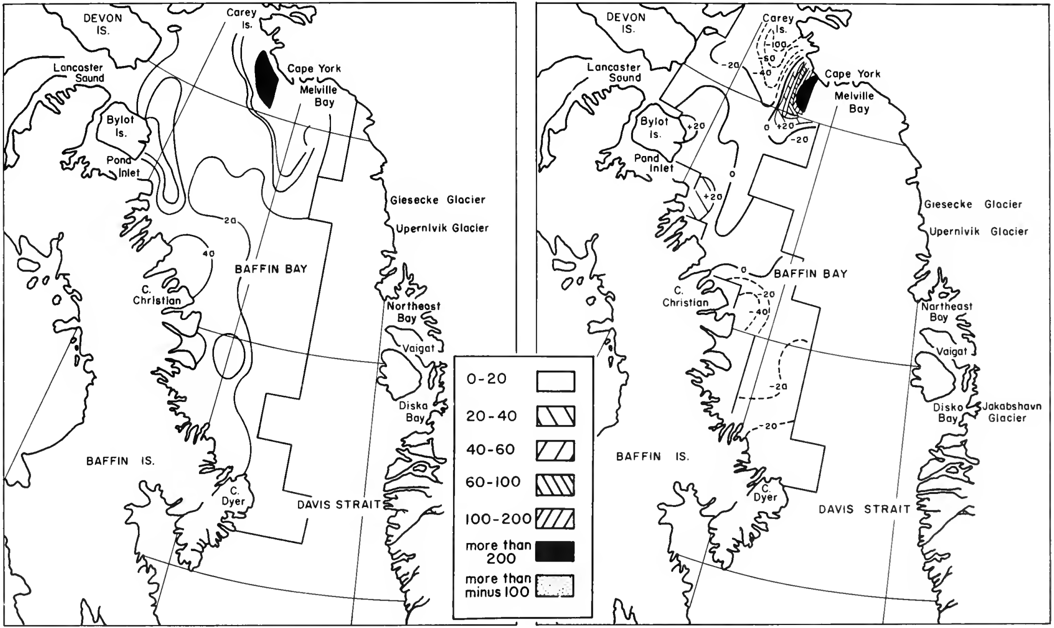

Figure 29.—Iceberg Concentration, 21-28 September and Anomaly From 1964-69 Average.

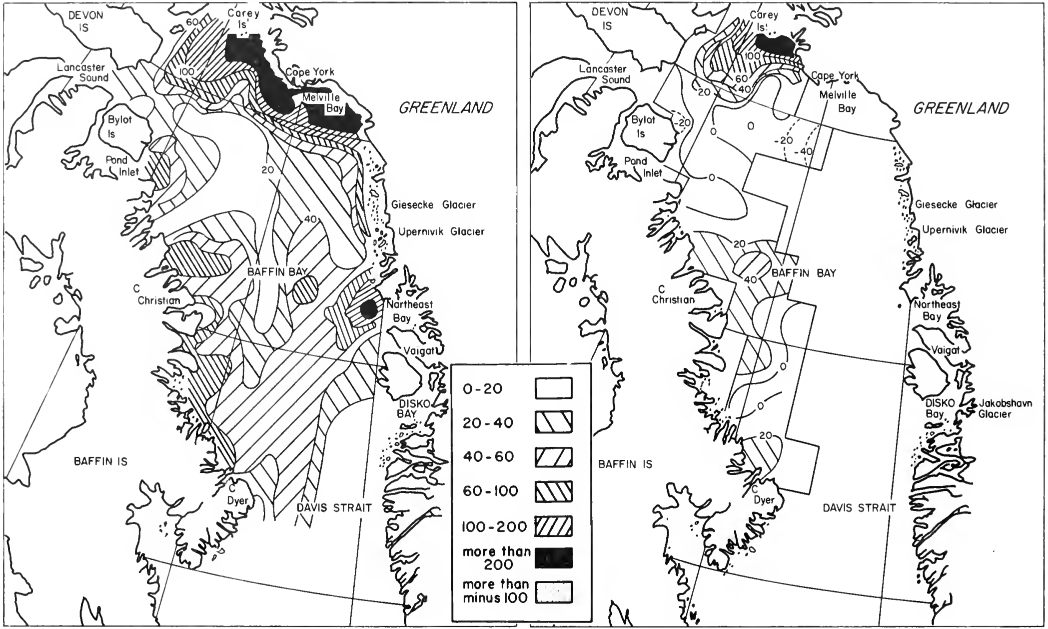

Figure 30.—Iceberg Concentration, 24 September 4 October 1968, and Anomaly From 1964-69 Average.

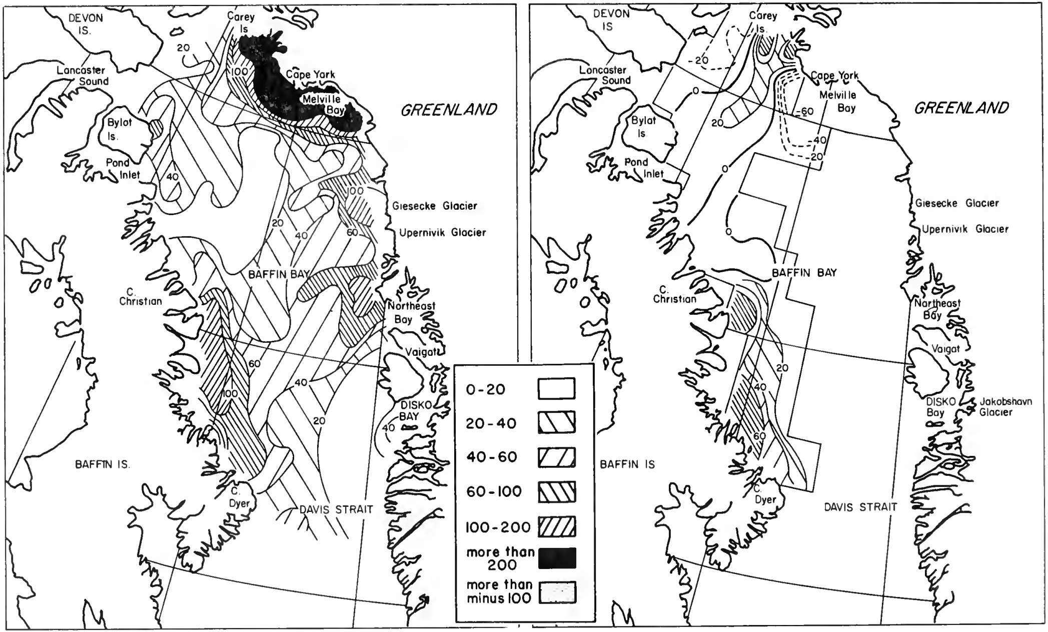

Figure 31.—Iceberg Concentration, 18-23 September 1969, and Anomaly From 1964-69 Average.

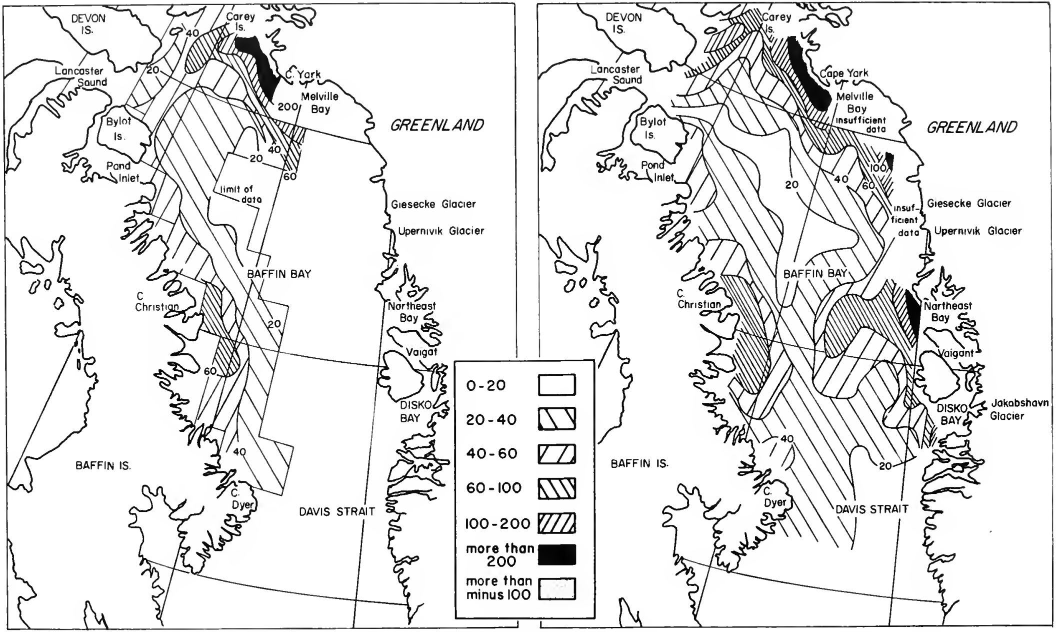

Figure 32.—Average September/October Iceberg Concentration 1964-69 and Composite Average July, August, September, October 1948, 1949, 1964-69.

The July chart for 1948 shows a well developed tongue extending from Disko Bay, and little if any indication of a tongue from Northeast Bay. The August chart for 1949 and the September charts for 1968 and 1969 show well developed tongues from Northeast Bay, with no indication of a tongue from Disko Bay in 1968, and small tongues in 1949 and 1969. It appears that the difference between the July and the August or September charts may be a normal seasonal phenomenon. According to the *Ice Atlas for the Northern Hemisphere* (U.S. Hydrographic Office, 1955), sea ice normally clears from Disko Bay in June or July and from Northeast Bay in July. Thus icebergs calved in Disko Bay are released from sea ice sooner than those calved farther north in Northeast Bay. This would result in the season's production of icebergs from Disko Bay appearing as a tongue in July and then dissipating in August or September as they drifted northward or westward. Meanwhile another tongue would be formed off Northeast Bay as the icebergs were released from the sea ice in that area.

Indications of southwestward tending tongues between 73N and 75N are found on the charts for July 1948, August 1949, and September 1969.

Very heavy concentrations of icebergs are usually found in northern Melville Bay, along the Greenland coast in the vicinity of Cape York, and around the Carey Islands. Many of the icebergs found in these areas drift there in the north-flowing West Greenland current. In some years the heavy iceberg concentrations continue across northern Baffin Bay to Ellesmere and Devon Islands on the Canadian side of Baffin Bay. Off Baffin Island heavy iceberg concentrations are typically found in the general vicinity of Pond Inlet, off Cape Christian, and north of Cape Dyer. The largest concentrations are found off Cape Christian, probably due to the shallow area which extends off-shore in this area, and the confluence of the two iceberg routes mentioned previously, directly across Baffin Bay and north through Belville Bay. As an example of the grounding of icebergs in the shallow water off Cape Christian, a large iceberg was grounded a short distance from the beach there for 2 years. The iceberg concentration north of Cape Dyer appears most prominent in July and August, rather than September or October, indicating that the concentrations may be at least partially due to the confluence of icebergs drifting north through Melville Bay and those coming directly across Baffin Bay from Disko Bay in the summer.

Deviations from the average 1964–69 iceberg distribution shown in figures 28 through 31 document an interesting progression of positive anomalies in northern Baffin Bay during the period 1966 through 1969. In September 1966 there was a deficiency of icebergs in northern Baffin Bay near Cape York. September 1967 found large numbers of icebergs extending westward past Cape York in a broad band. By September 1968 the center of the large excess of icebergs had moved northwest to the vicinity of the Carey Islands. Finally in September 1969 it appears that the excess of icebergs in the area began to dissipate. Apparently the iceberg excess was released into Baffin Bay in the summer of 1966 when the average August air temperature at Upernavik was 18°C above normal. The icebergs had probably not drifted as a group to the vicinity of Cape York in time to be observed on the September flight. However they were beginning to show up south of Cape Christian as can be inferred from the positive anomaly in that area in September. 1967 was a very heavy iceberg season on the Grand Banks; apparently the potential for the heavy season was due to the excess of icebergs which moved directly across Baffin Bay during the late summer and fall of 1966. The icebergs which moved northwest toward Melville Bay evidently were not a major threat to the Grand Banks until 1970, 3 years later. However in 1970 weather conditions were unfavorable for a heavy iceberg season and a light season was recorded.

The above data seem to indicate that the iceberg danger on the Grand Banks can come about by two routes. One, icebergs drift directly across Baffin Bay and threaten the Grand Banks the following year; and two, icebergs drift north into Melville Bay to threaten the Grand Banks during the next several years. Which route the icebergs will take probably is quite dependent on wind and ocean current conditions as they move from glacier fronts into or through the West Greenland Current. It is quite possible that in a given group of icebergs some will follow the northern route and others will follow the direct route. It is possible that the potential for very large iceberg seasons on the Grand Banks is a result of large numbers of icebergs from both routes coinciding in their time of exiting Baffin Bay to drift south.

In any event it appears that the direct route across Baffin Bay is a very important one for icebergs, and one which can provide a late and rapidly developing threat to the Grand Banks.

December Northern Iceberg Surveys

December iceberg survey flights along the Labrador and Baffin Island coasts have been made during the years 1963 through 1969. The timing of the December flights has been remarkably consistent, all having taken place the first part of December. December flights do not extent farther off-shore from the Labrador coast than 200 miles. Therefore the data does not cover the central Labrador Sea or the west Greenland coast south of 66N. The results of the individual surveys are shown in figures 33 through 39 in terms of icebergs per two square degrees. The methods used in plotting and contouring the data are the same as for the fall flights. Figure 40 shows average iceberg conditions based on 4 to 7 year's data.

The largest iceberg concentration in December is found in the vicinity of Cape Christian, as was the case for the fall surveys. There is some indication that the concentration off Cape Christian increases slightly between fall and winter. As was the case in the fall surveys there is a tendency for icebergs to concentrate north of Cape Dyer. Movement of icebergs directly across Baffin Bay is only slightly discernable in the average chart, however it shows up more clearly in the individual charts, particularly the one for 1969. Continuing southward the next major iceberg concentrating area is the hook-like peninsula between Cumberland Sound and Frobisher Bay. In the entrance to Hudson Strait there normally appears to be a slight break in iceberg concentration. This is probably related to the flow of currents in and out of the Strait. South of Hudson Strait icebergs again tend to concentrate, probably because of shallow areas extending well off-shore between the Strait and Hopedale.

January Preseason Iceberg Surveys

The purpose of the January flights has been to monitor the progress of the icebergs as they drift south toward the Grand Banks, and to estimate how heavy the iceberg season will be. Figures 41 through 47 show January iceberg distributions for the various years 1963 and 1965 through 1970 in icebergs per two square degrees along the Baffin Island and Labrador coasts. As was the case in the December flights the coverage does not extend offshore more than about 200 miles at most. Figure 48 based on 4 to 7 years data, represents average January iceberg conditions in this area. The general pattern of iceberg concentrations is similar to the December pattern with accumulations of icebergs found between Cumberland Sound and Frobisher Bay, and along the northern Labrador coast. However, the average total iceberg count south of Cumberland Sound increases by a factor of about 2 between December and mid-January. The average southern limit of icebergs in both December and January is about 53N.

The correlation between the number of icebergs in January south of 60N, as far north as coverage has been uniform, and the number of icebergs which drift south of 48N into trans-Atlantic shipping routes during March through July is low, as is shown by figure 58. The correlation coefficient is only 0.19 using a least squares fit between the two variables. Use of data north to 64N, for the years in which it was available, did not improve the correlation. This low correlation between January iceberg potential along the Labrador coast and iceberg severity on the Grand Banks in the following months emphasizes the importance of other factors in January, primarily winter winds, in determining the severity of the iceberg season on the Grand Banks.

February Preseason Iceberg Surveys

The preseason iceberg surveys carried out in February are the most important preseason Ice Patrol activities of the U.S. Coast Guard. The February surveys are directly related to the operation of the Ice Patrol in that during a number of years icebergs have begun to threaten the Grand Banks in February. Also the results of the February flights are a major factor in deciding when to start routine iceberg patrols of the Grand Banks and daily broadcasts of iceberg positions.

Unfortunately the so-called February flights have not all been made at the same time each years. In fact there have been years in which flights have not been made in February, but rather were made in early March instead. In order to analyse these surveys more uniformly they have all been adjusted to a common date of 25 February. This was done by "drifting" the icebergs sighted on the various surveys forward or

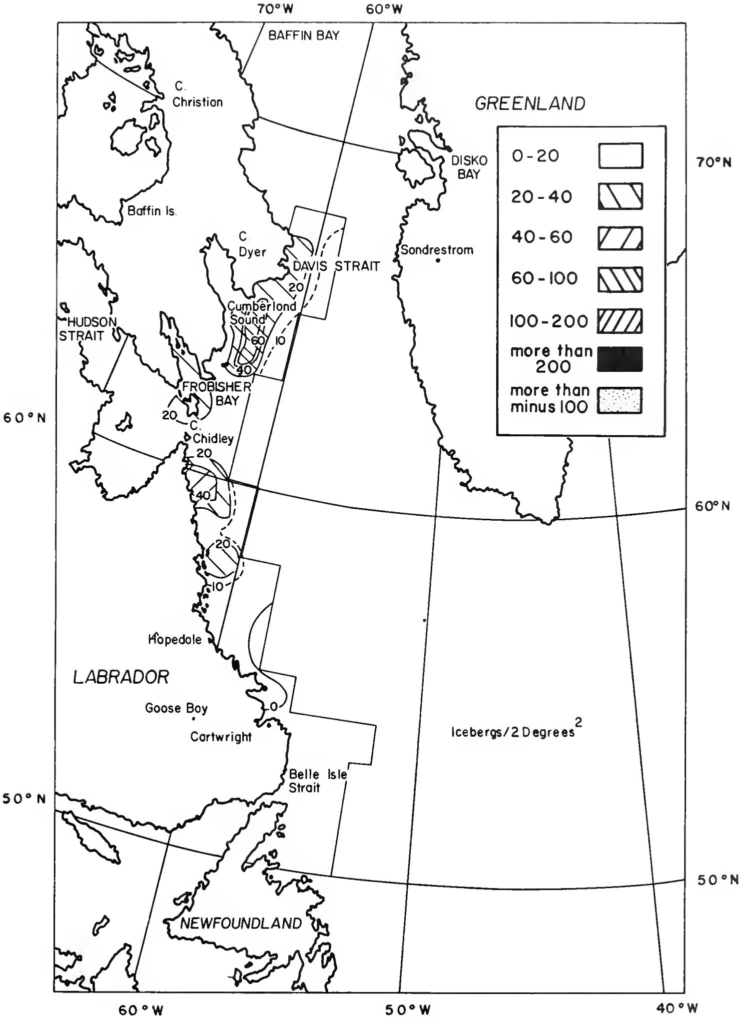

Figure 33.—Iceberg Concentration, 3-5 December 1963.

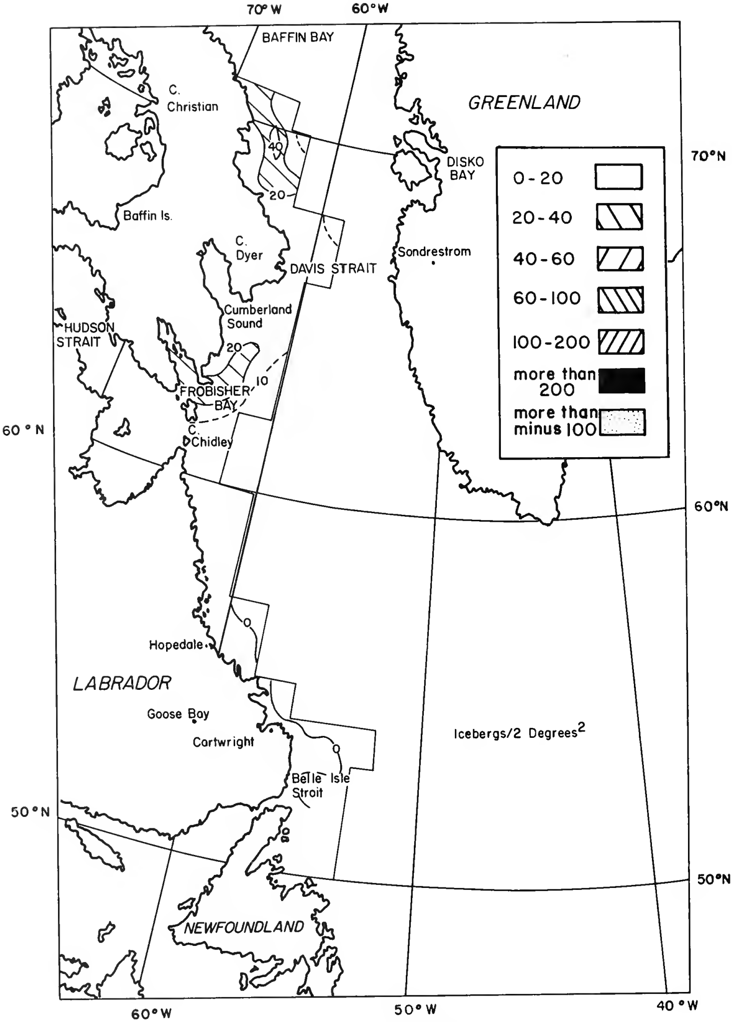

Figure 34.—Iceberg Concentration, 6-8 December 1964.

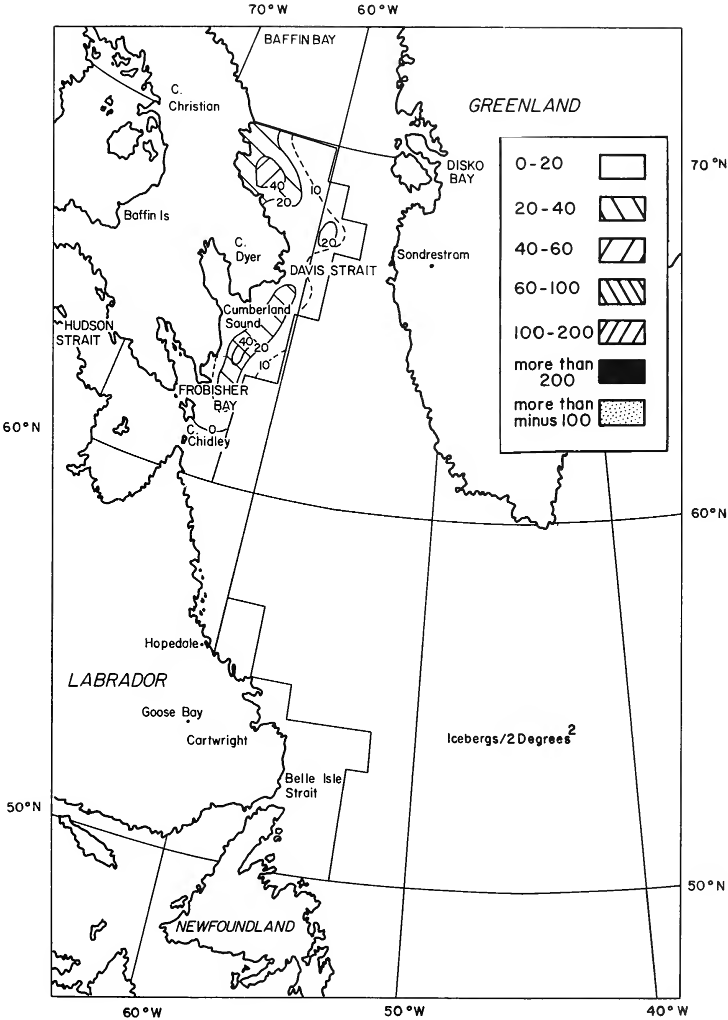

Figure 35.—Iceberg Concentration, 9-11 December 1965.

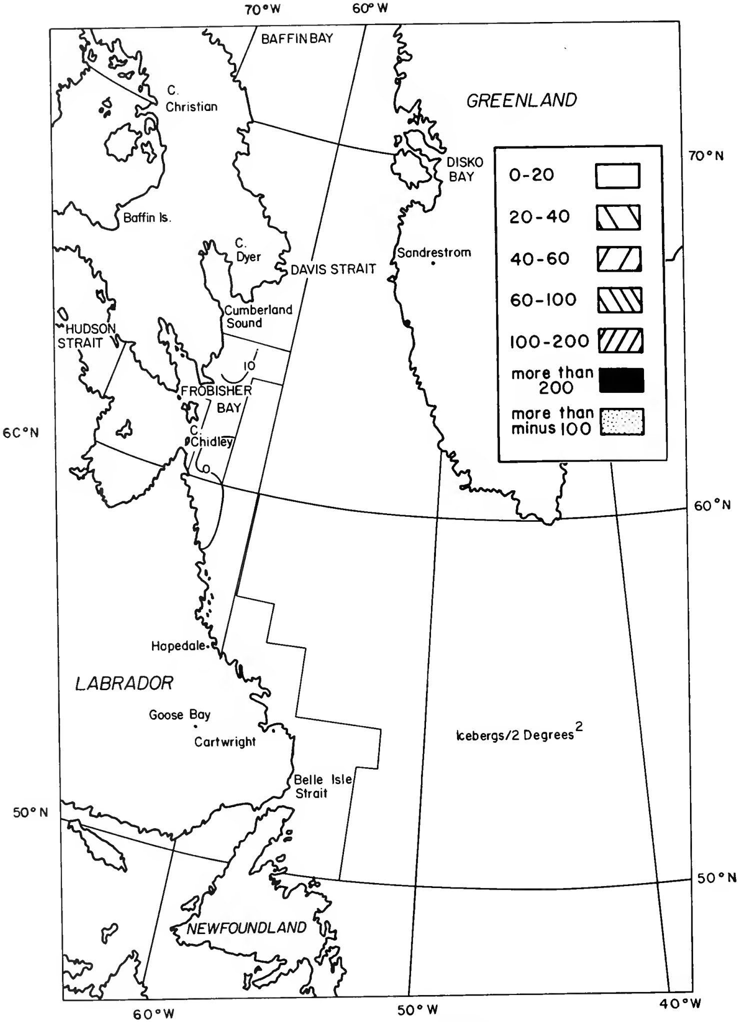

Figure 36.—Iceberg Concentration, 8-9 December 1966.

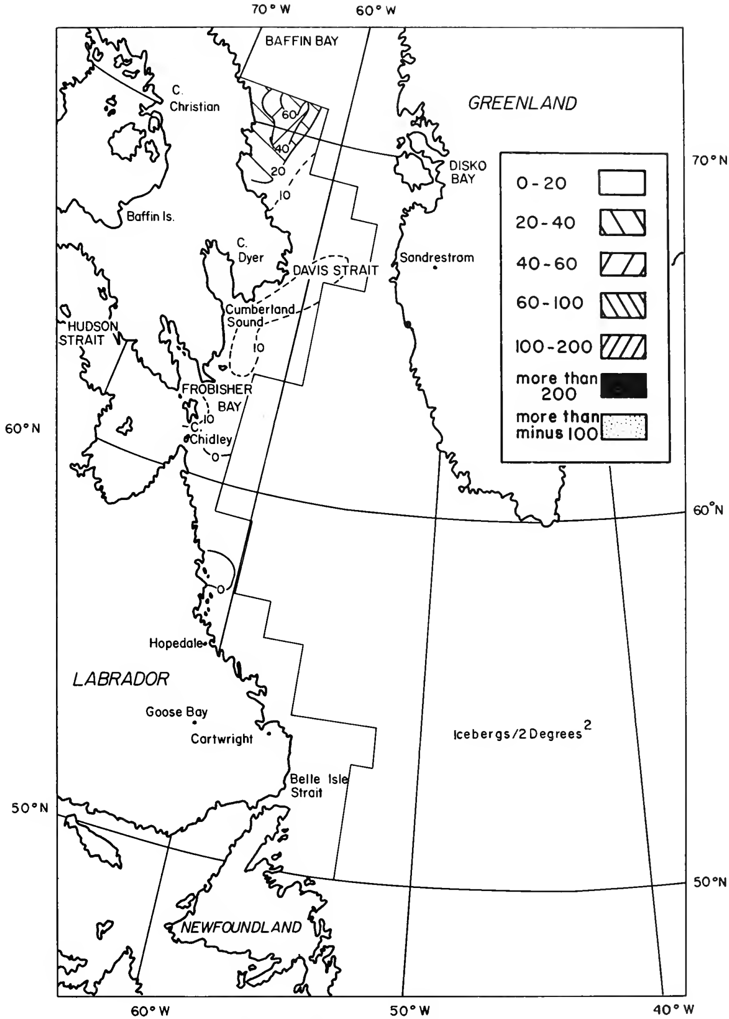

Figure 37.—Iceberg Concentration, 6-9 December 1967.

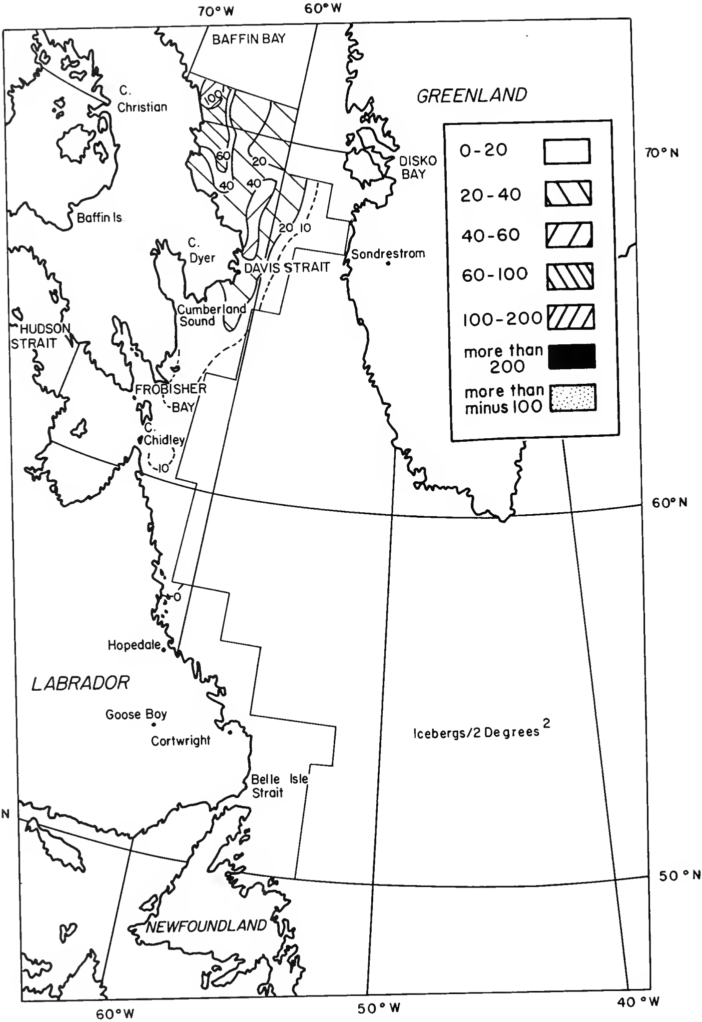

Figure 38.—Iceberg Concentration, 5-10 December 1968.

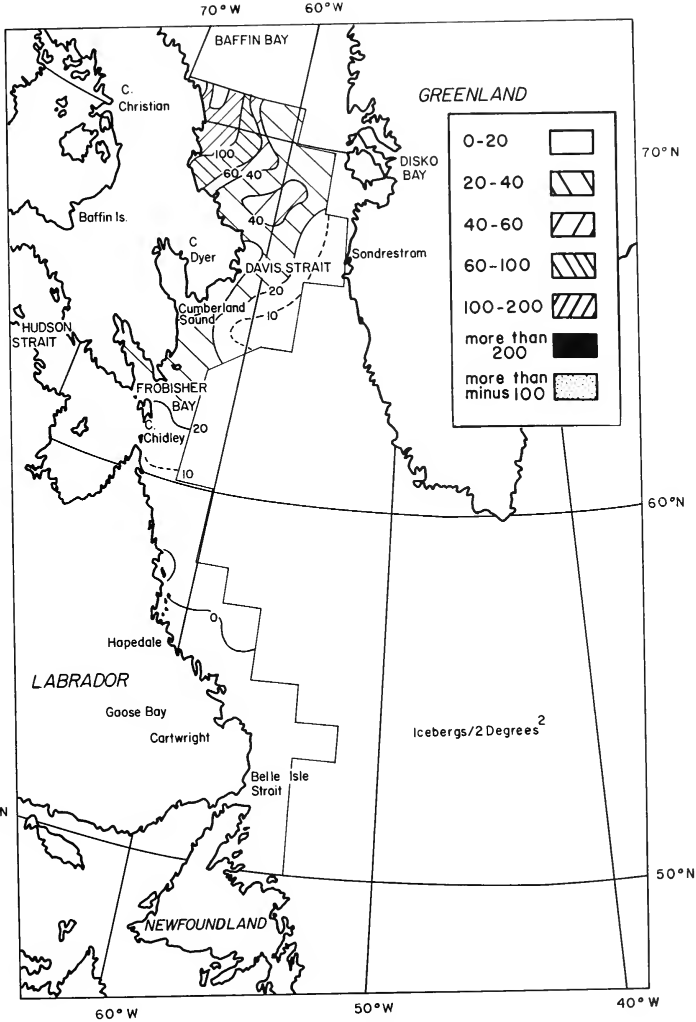

Figure 39.—Iceberg Concentration, 11-16 December 1969.

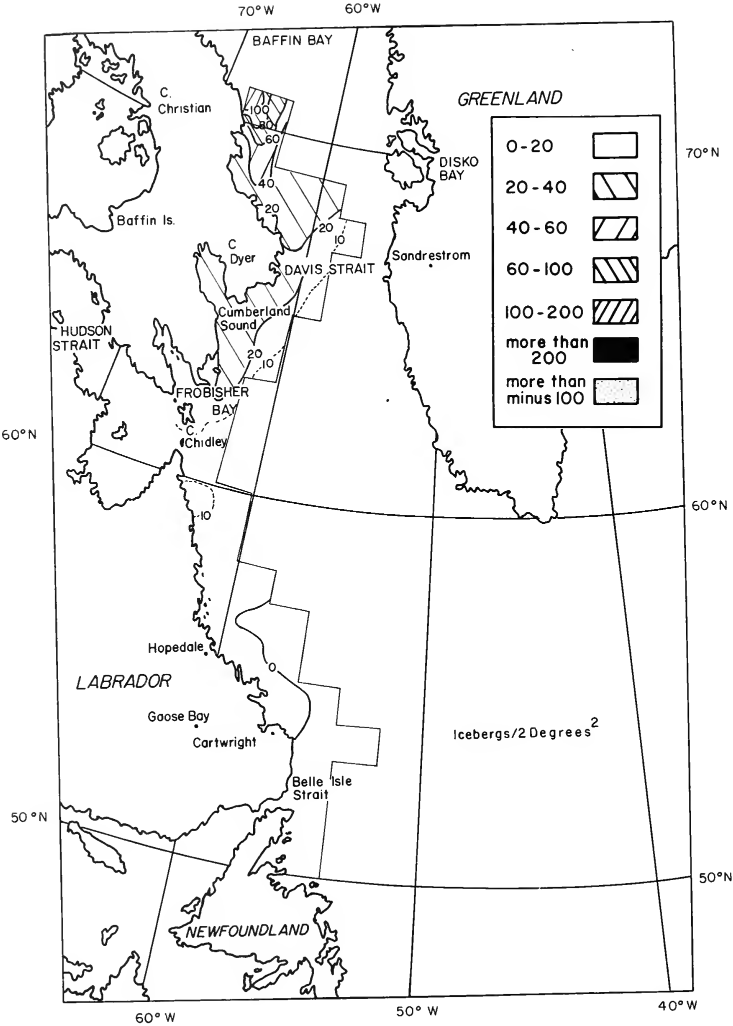

Figure 40.—Iceberg Concentration, December Average 1963-69.

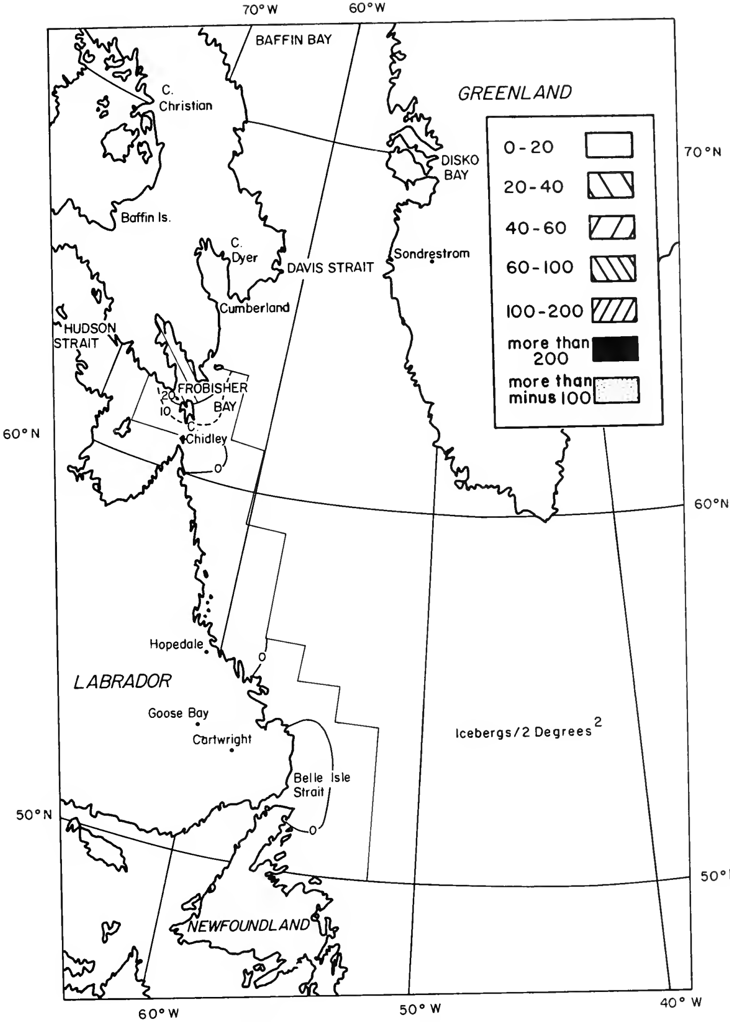

Figure 41.—Iceberg Concentration, 13-14 January 1963.

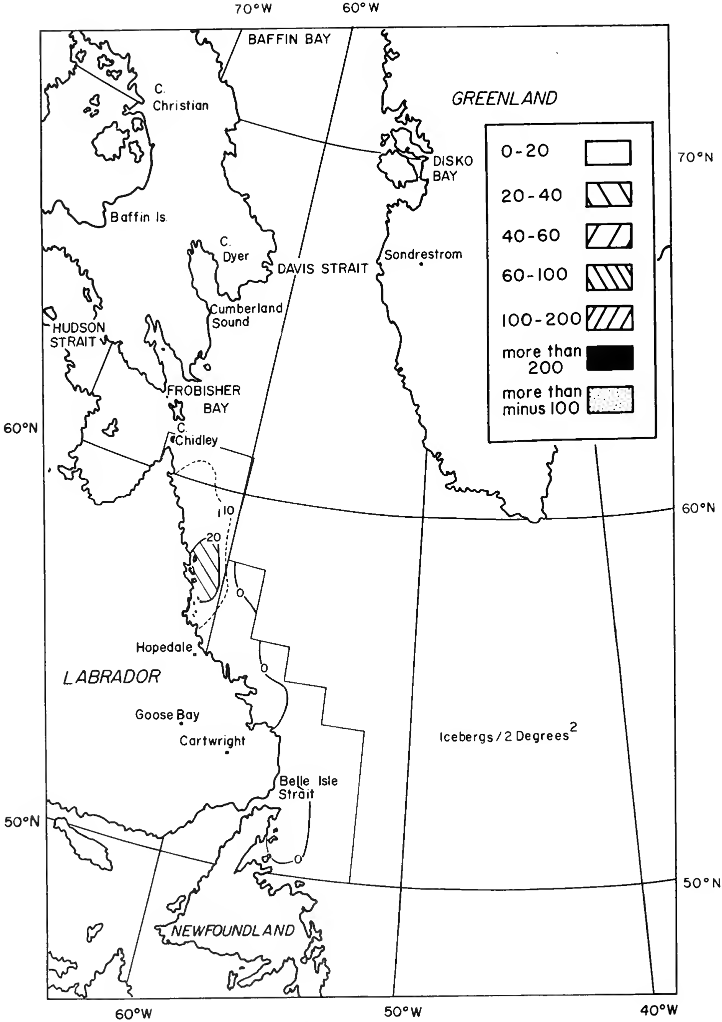

Figure 42.—Iceberg Concentration, 7 January 1965.

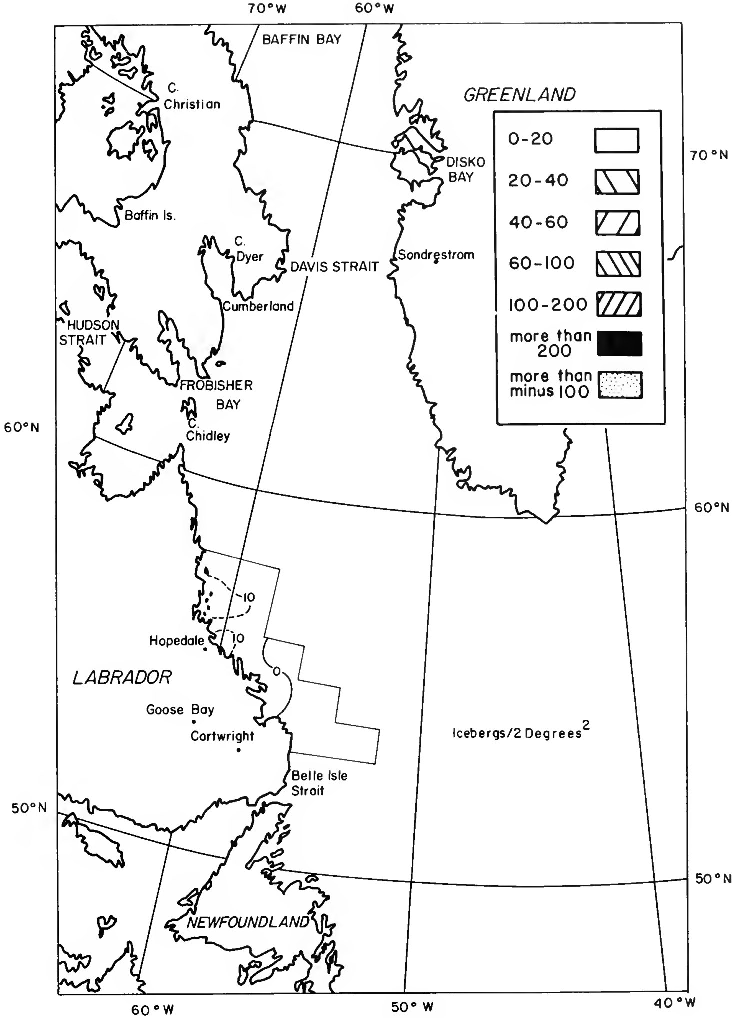

Figure 43.—Iceberg Concentration, 20 January 1966.

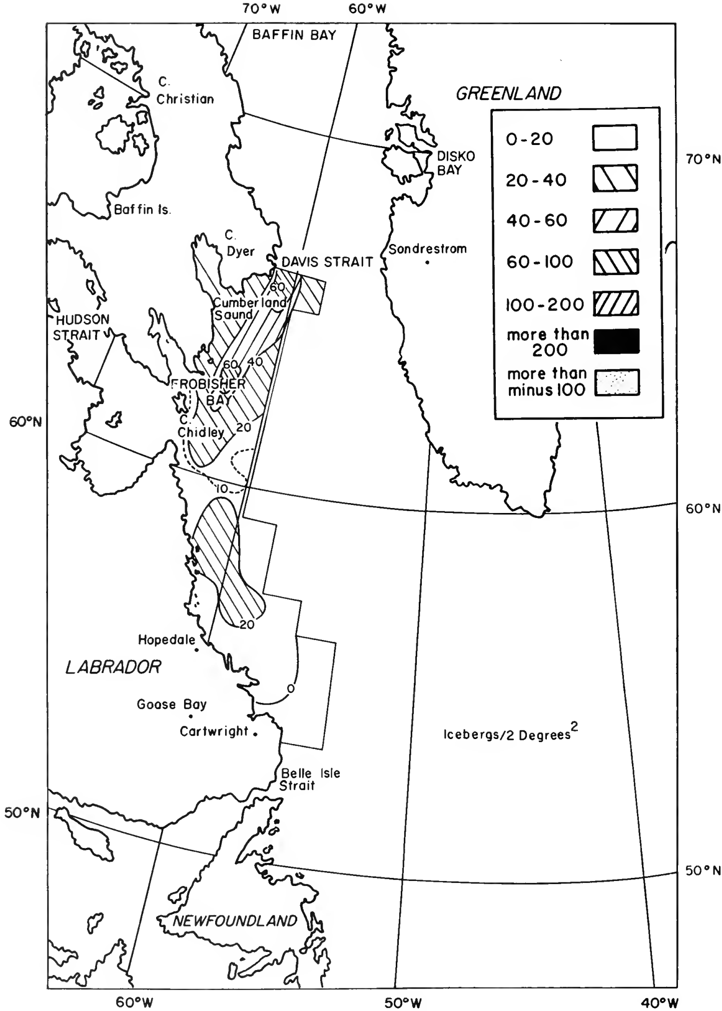

Figure 44.—Iceberg Concentration, 25-26 January 1967.

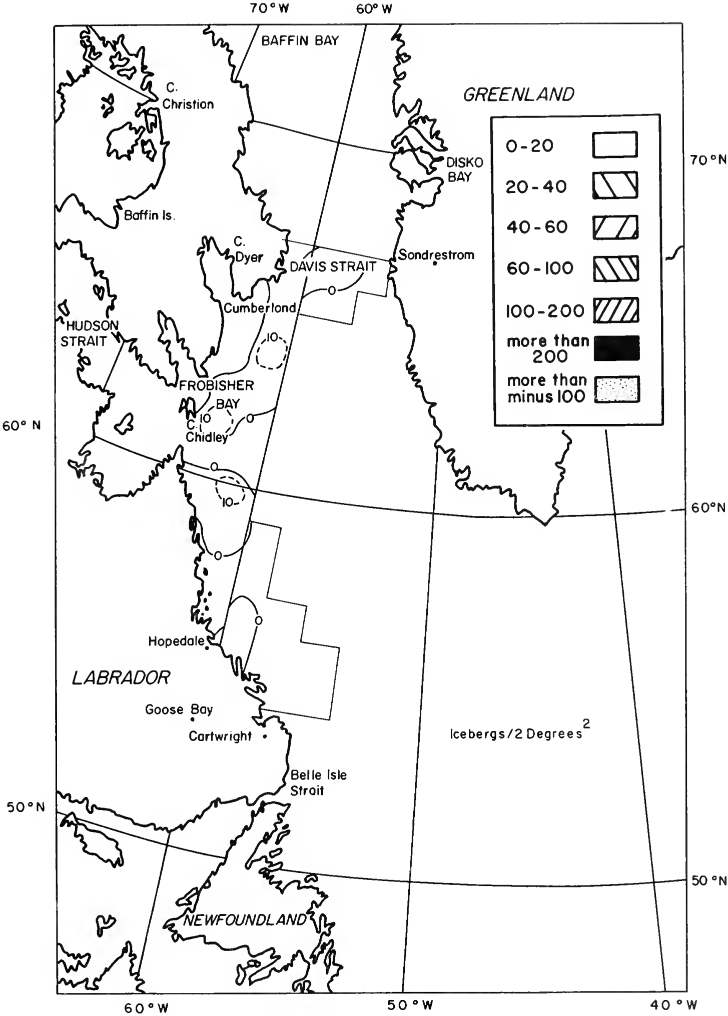

Figure 45.—Iceberg Concentration, 22-25, January 1968.

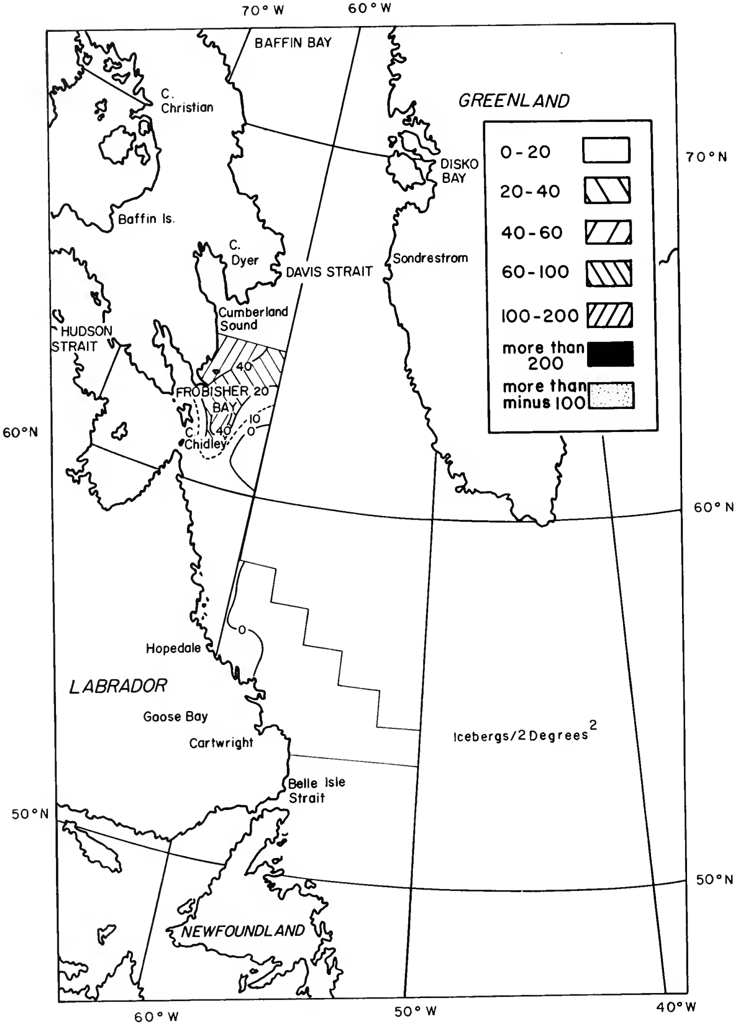

Figure 46.—Iceberg Concentration, 27 January-2 February.

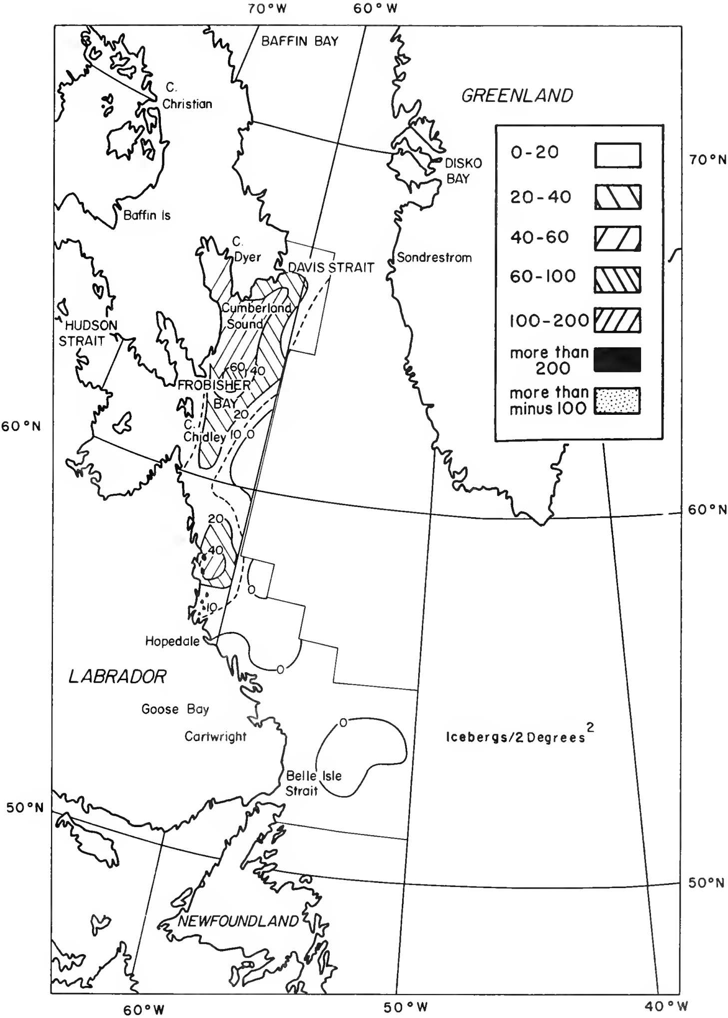

Figure 47.—Iceberg Concentration, 20-24 January 1970.

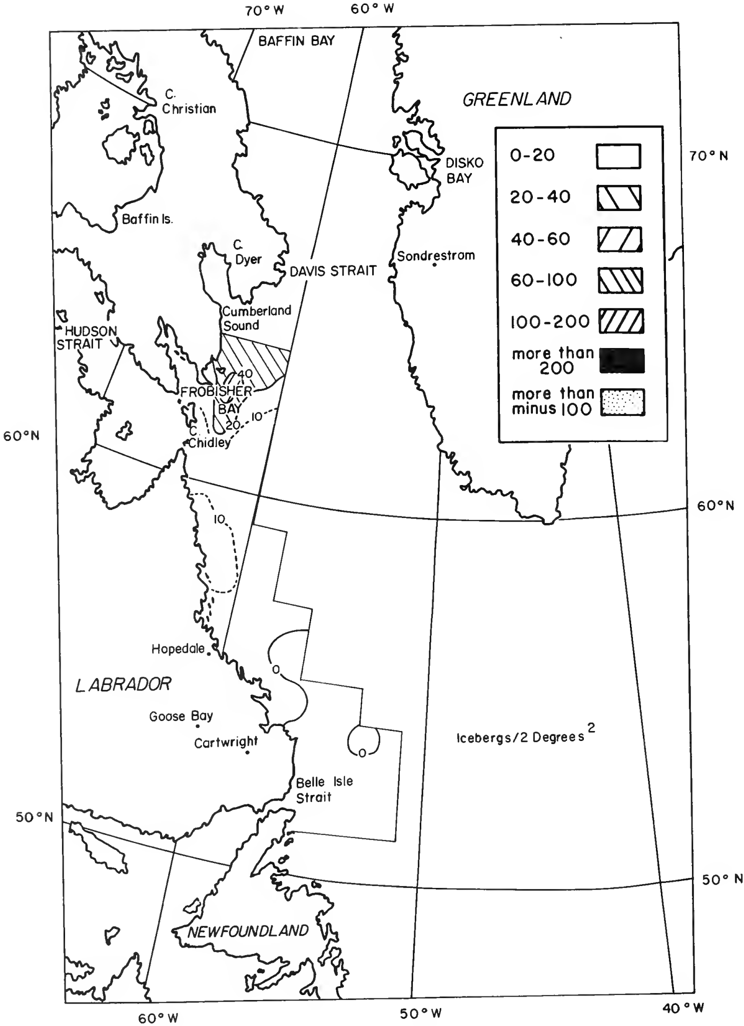

Figure 48.—Iceberg Concentration, January Average, 1963-70.

backward in the Labrador Current at a rate of 7 miles per day (selected as the best average of several estimates of the drift rate of icebergs along the Labrador coast reported in the various Reports of the International Ice Patrol Service in the North Atlantic Ocean). The actual dates of the "February" survey are given below:

27 February–4 March 1970
19–20 February 1969
27–28 February 1968
25–27 February 1967
9–10 February 1966
11 March 1965
26–28 February 1964
13–14 March 1963

February iceberg concentrations along the Labrador coast for the years 1963 through 1970 are shown in figures 49 through 56 in icebergs per two square degrees. Average iceberg concentrations for February are shown in figure 57. The average chart and the charts for the various years indicate that icebergs extend as a band down the Labrador coast with concentrations frequently occuring near 57N to 58N, near 55N to 56N, and near the Strait of Belle Isle. The average total iceberg count south of Hudson Strait increases by a factor of about 4 between mid-January and late February, and by a factor of about 10 between early December and late February.

The correlation between the number of icebergs south of 61N on the February survey and the number of icebergs drifting south of 48N is fair, as shown in figure 58. The actual correlation coefficient is 0.61 using a least squares fit between the two variables.

The correlation between the northern boundary of the southernmost one degree latitude interval containing 10 icebergs on the February survey and the date the first group of icebergs drift south of 48N is also given in figure 58. As indicated by a correlation coefficient of 0.77 there is a fairly good relationship between the southern extent of icebergs on the February flights and when the icebergs will begin to drift south of 48N. The average rate of drift which can be derived from this relationship, based on a reasonable path of iceberg drift, is 6.25 miles per day, a value in fair agreement with the drift rate of 7 miles per day estimated previously.

Conclusion

The primary purpose of this report has been to present an analysis of the geographical distribution of icebergs in certain areas in the fall and winter during the period 1963–70. Admittedly the length of the record is quite short for such an analysis. However it can be noted that the average number of icebergs drifting south of 48°N onto the Grand Banks during the period 1963–70 is about 180 per season, not greatly below the 1946–70 average of 229. Also the 1963–70 period has included a very heavy (441 icebergs) and a very light (0 icebergs) season. In the course of analyzing fall and winter iceberg distributions, fair to good correlations between January and February distributions and subsequent iceberg conditions on the Grand Banks have been noted. Further research should be directed toward analysis of these January and February distributions in connection with other environmental parameters such as wind, temperature, and ocean currents with a goal of developing accurate methods of forecasting the beginning, duration, and severity of the iceberg season on the Grand Banks. Meanwhile iceberg data collection in January and February should continue with the dates of the surveys being stabilized, preferably centered on 15 January and 25 February.

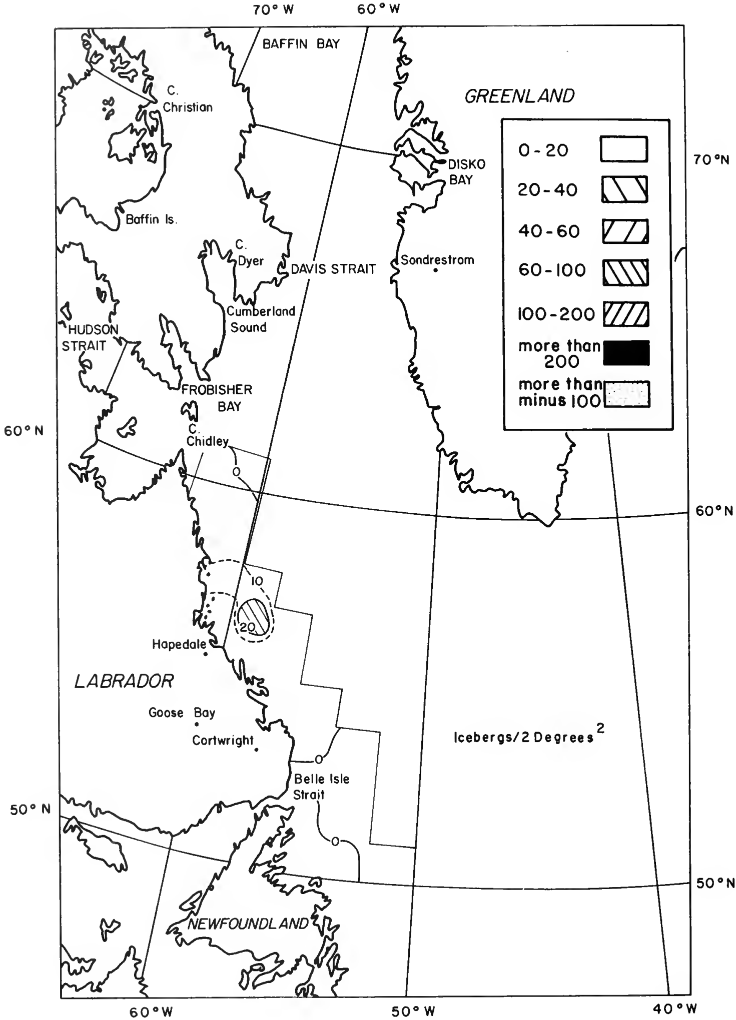

Figure 49.—Iceberg Concentration, February 1963.

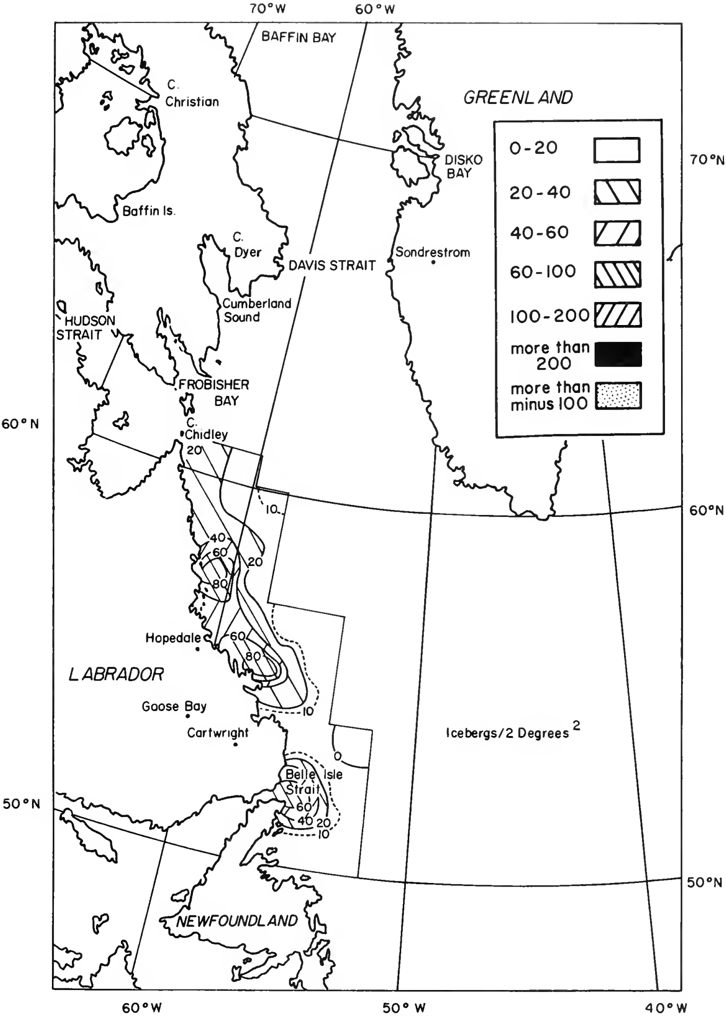

Figure 50.—Iceberg Concentration, February 1964.

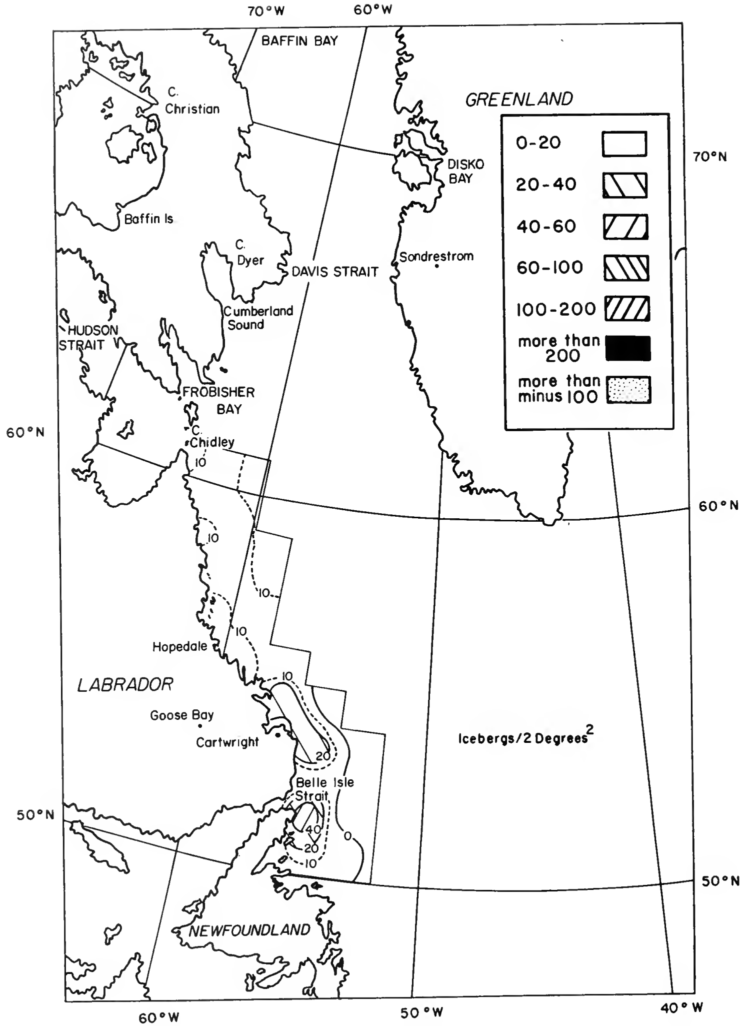

Figure 51.—Iceberg Concentration, February 1965.

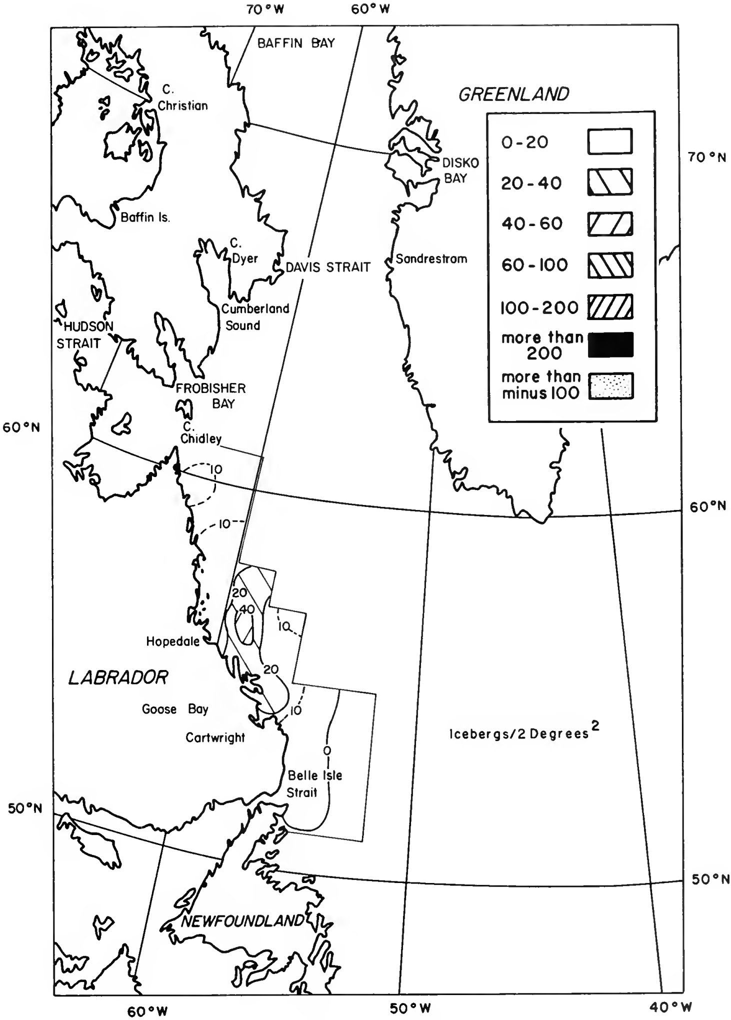

Figure 52.—Iceberg Concentration, February 1966.

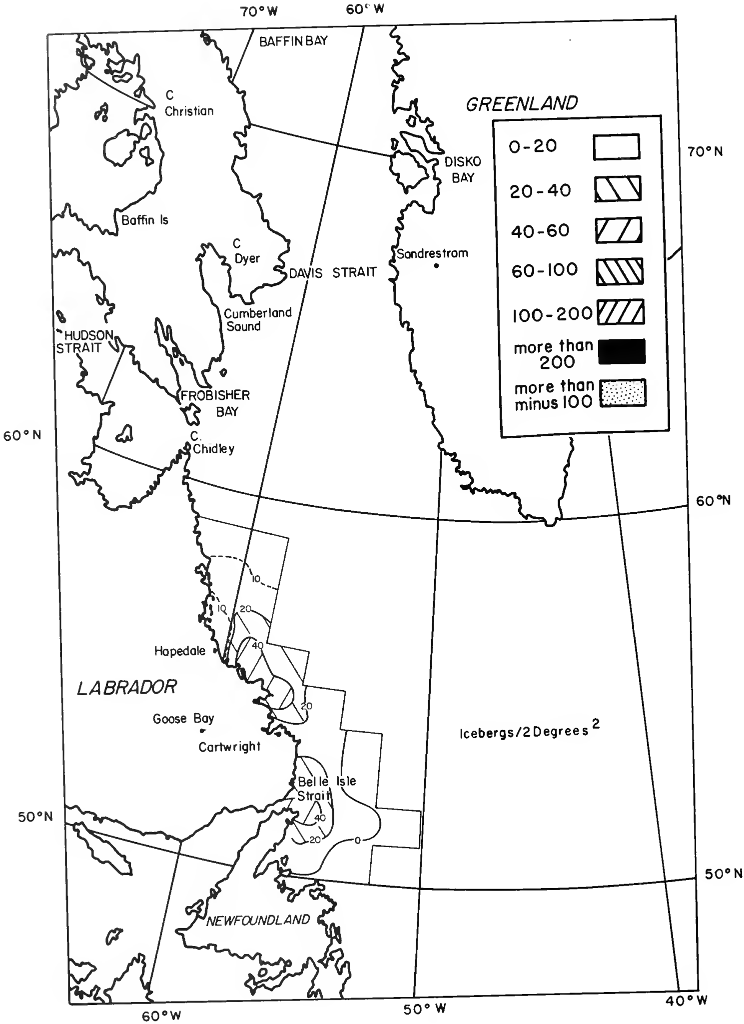

Figure 53.—Iceberg Concentration, February 1967.

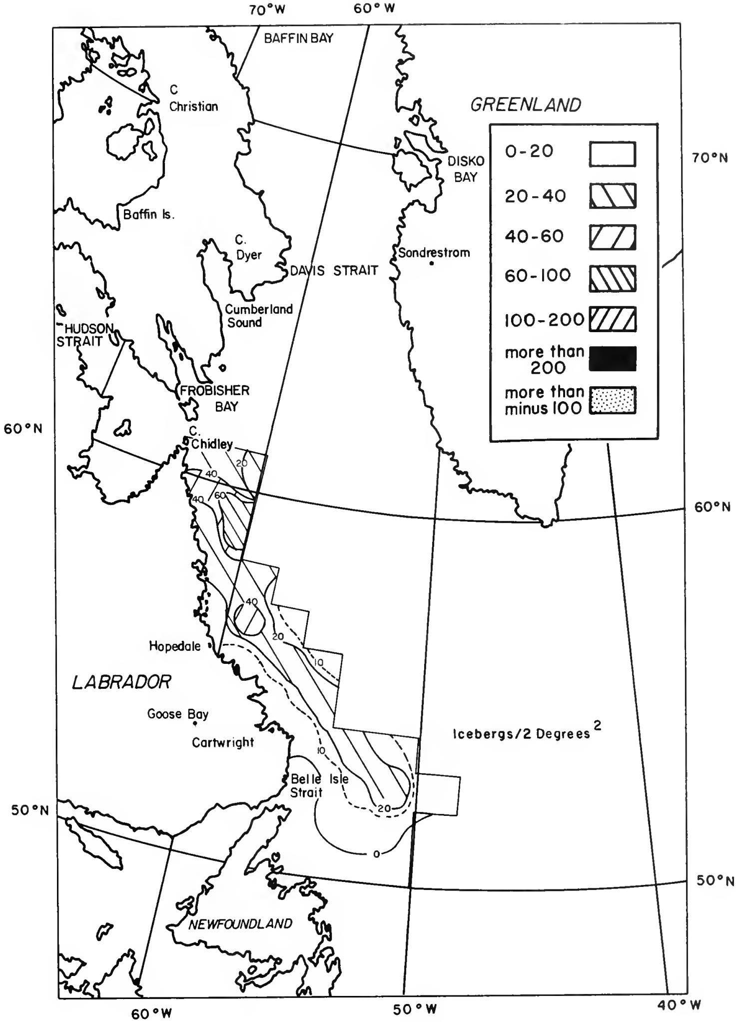

Figure 54.—Iceberg Concentration, February 1968.

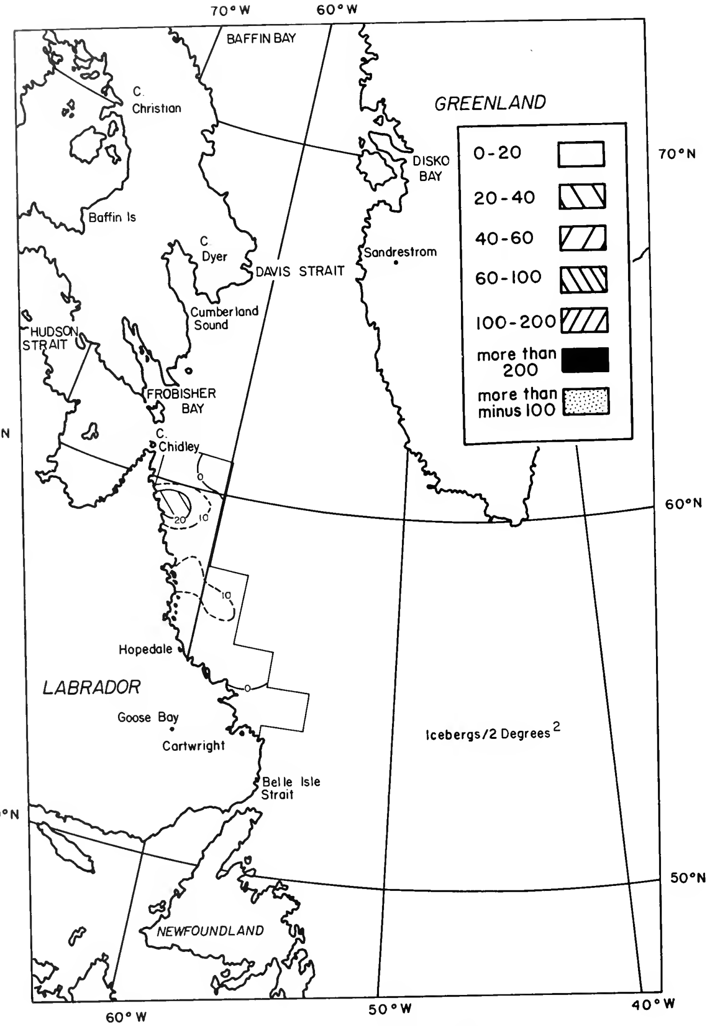

Figure 55.—Iceberg Concentration, February 1969.

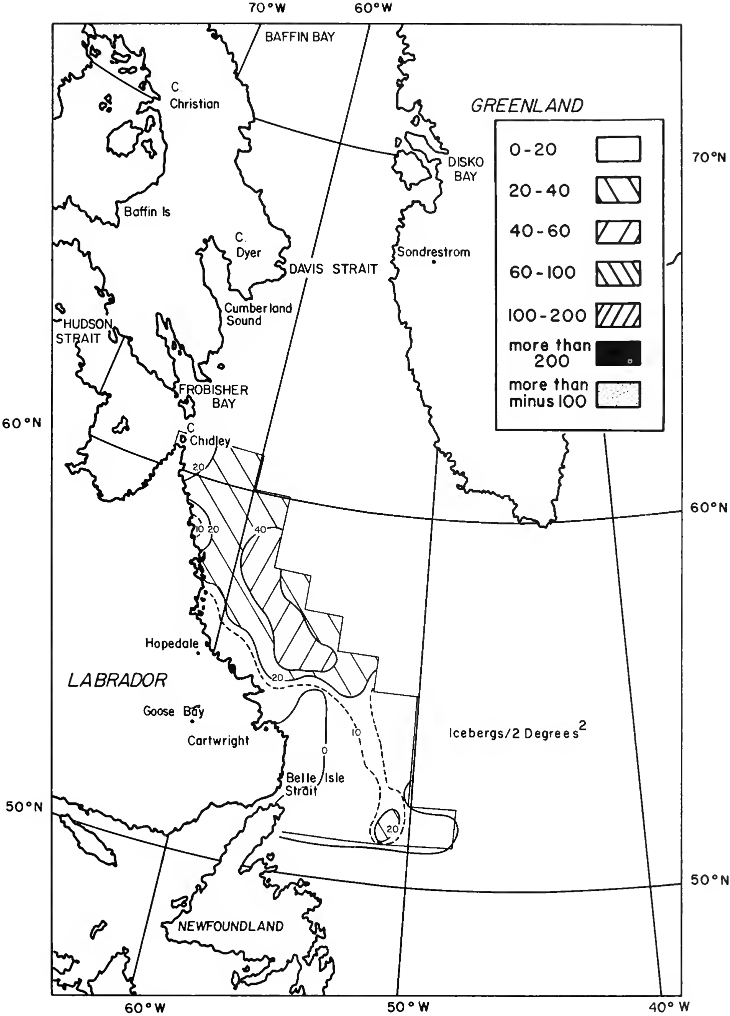

Figure 56.—Iceberg Concentration, February 1970.

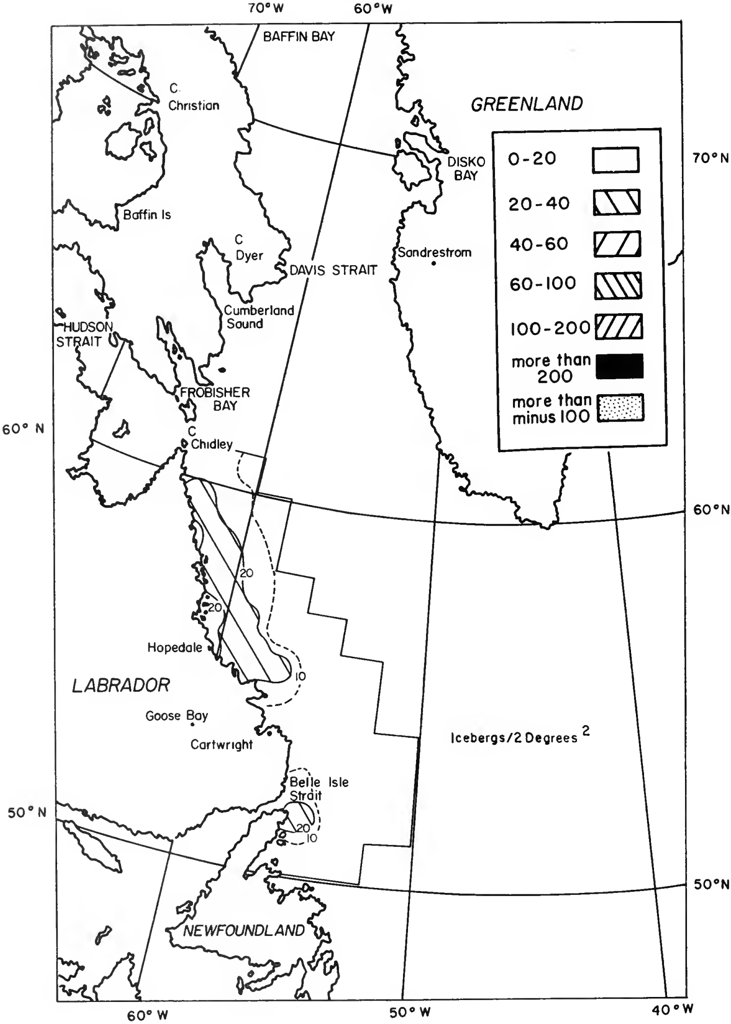

Figure 57.—Iceberg Concentration, February Average, 1963-70.

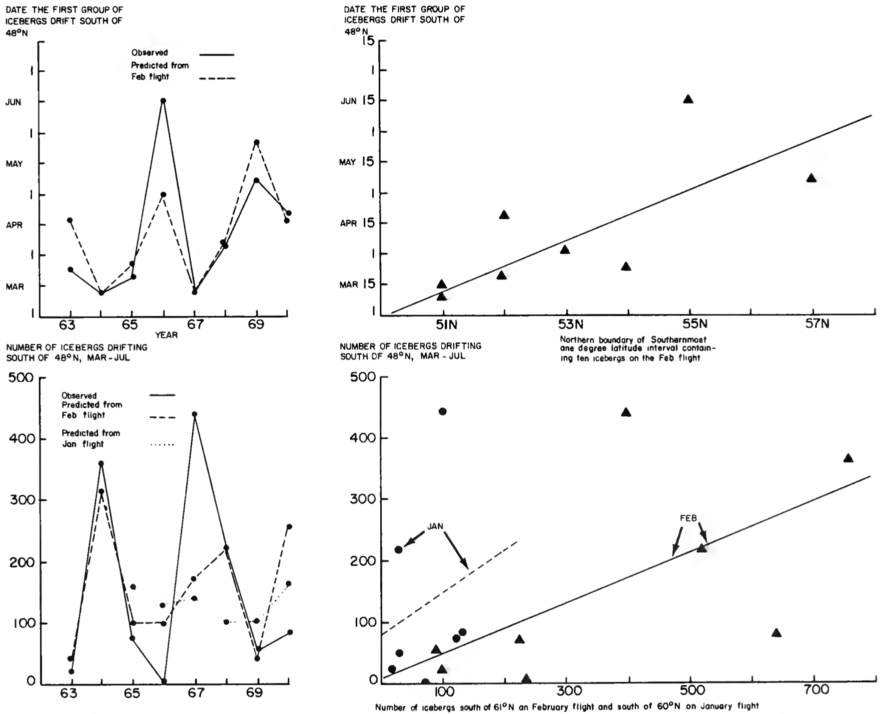

Figure 58.—Correlation of Iceberg Severity and Arrival Dates on the Grand Banks With Preseason Flights in January and February.

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DEPARTMENT OF TRANSPORTATION

COAST GUARD

BULLETIN NO. 57

Report of the International Ice Patrol Service in the North Atlantic Ocean

SEASON OF 1971

CG-188-26

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Bulletin No. 57

REPORT OF THE INTERNATIONAL ICE PATROL SERVICE IN THE NORTH ATLANTIC OCEAN

Season of 1971

CG-188-26

FOREWORD

Forwarded herewith is Bulletin No. 57 of the International Ice Patrol describing the Patrol services, and ice observations and conditions during the 1971 season.

R. H. SCARBOROUGH
Acting Chief, Office of Operations

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F: None
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PREFACE

This report is the 57th in a series of annual reports on the International Ice Patrol Service in the North Atlantic Ocean. It contains information on Ice Patrol organization, communications, and operations and on ice and environmental conditions which existed during the 1971 International Ice Patrol year.

The author of this paper, Commander Eugene A. DELANEY, USCG acknowledges ice and weather data provided by the Canadian Atmospheric Environment Service, weather and oceanographic data provided by the U. S. Naval Weather Service, and oceanographic data provided by the U. S. Coast Guard Oceanographic Unit. Acknowledgement is also made to Senior Chief Marine Science Technician P. Riley FLOWERS, Marine Science Technician First Class James A. SHAFER, and Yeoman Second Class Bruce S. COLLINS of the United States Coast Guard for their assistance in the preparation of the manuscript and illustrations for this report.

The final section of this Report is a paper by Lieutenant Commander Charles W. MORGAN, U.S. Coast Guard, the assistant Ice Patrol Officer during the early portion of this season, entitled Long Term Trends in the Iceberg Threat in the Northwest Atlantic.

The 1971 International Ice Patrol Service in the North Atlantic Ocean was conducted by the United States Coast Guard under the provisions of Title 46, United States Code, Sections 738, 738a through 738d, and the International Convention for the Safety of Life at Sea, 1960, Regulations 5 through 8. The International Ice Patrol is a service for observing and disseminating information on ice conditions in the Northwest Atlantic Ocean. During the ice season, the southeastern, southern, and southwestern limits of the regions of icebergs in the vicinity of the Grand Banks of Newfoundland are guarded for the purpose of informing passing ships of the extent of this dangerous region. The International Ice Patrol also studies ice conditions in general with emphasis on the formation, drift and deterioration of icebergs, and assists ships and personnel requiring aid within the limits of operation of the Ice Patrol forces.

The International Ice Patrol is directed from the Ice Patrol Office located at the U. S. Coast Guard Base, Governors Island, New York. The Office gathers ice and environmental data from a variety of United States and Canadian sources, maintains an ice plot, forecasts ice conditions, prepares the twice-daily Ice Bulletin, replies to requests for special ice information, and executes operational control of the Aerial Ice Reconnaissance Detachment, the Ice Patrol oceanographic ship, and any surface patrol ship assigned to Ice Patrol duties.

Rear Admiral Benjamin F. ENGEL, U. S. Coast Guard was Commander, International Ice Patrol during the entire season. Commander Eugene A. DELANEY, U. S. Coast Guard was directly responsible for the management of the Patrol.

Preseason Ice Patrol flights were made in September 1970, and in January, February, and March 1971. The Aerial Ice Reconnaissance Detachment was deployed to Canadian Forces Base, Summerside, Prince Edward Island on 9 March 1971. The Detachment returned to the United States on 29 June 1971.

The 1971 Ice Season officially commenced at 0000 GMT, 10 March, when the first Ice Bulletin was issued, and continued until the final Bulletin was issued at 1200 GMT, 29 June 1971. Twice-daily Ice Bulletins were broadcast by the International Ice Patrol Radio Station Boston/NIK, U. S. Naval Radio Station Washington/NSS, Canadian Forces Radio Station Mill Cove/CFH, and Canadian Coastal Radio Station St. John's/VON. The Ice Bulletin was also included in the U. S. Marine Information Broadcast for the High Seas of the North Atlantic, a voice broadcast originating from the U. S. Coast Guard Radio Station Boston/NMF. A facsimile ice chart was also broadcast from Radio Boston once daily.

The U. S. Coast Guard Cutter EVERGREEN, commanded by Lieutenant Commander Robert E. PHELPS, U. S. Coast Guard, conducted oceanographic cruises for the Ice Patrol during April and May. The U. S. Coast Guard Cutter ROCKAWAY, commanded by Commander William T. ADAMS, U. S. Coast Guard, joined EVERGREEN during the May survey to conduct a multi-ship survey of the Labrador Current and the surrounding oceanic area. For the twelfth consecutive year, it was unnecessary to use a surface patrol cutter.

During the 1971 Season an estimated 62 icebergs drifted south of 48°N, a relatively light season. It is also estimated that another 11 icebergs drifted south of 48°N during July 1971 only to deteriorate before reaching 47°N.

AERIAL ICE RECONNAISSANCE

During the period 1 September 1970 to 31 August 1971 a total of 56 ice observation flights were flown. Preseason flights made in September, January, February, and March accounted for 17 flights, and the remaining 39 flights were made during the Season. There was no requirement for postseason flights. The objective of the preseason flights was to study the iceberg distribution in Baffin Bay and the Labrador Sea, and to assess the iceberg potential of the coming Season. The Season flight objective was to locate the southerly limit of the region of icebergs, to assess the iceberg potential for the near term in the area immediately north of the Grand Banks, and on 2 occasions to determine the iceberg distribution along the southern part of Labrador's eastern coast. The flight statistics shown in Table 1 do not include the flight time required to make the passages between U. S. Coast Guard Air Station, Elizabeth City, North Carolina and the operating bases for the Ice Patrol reconnaissance for crew relief or aircraft maintenance.

The reconnaissance aircraft were U. S. Coast Guard HC-130-B (Lockheed Hercules) four-engine planes from the Coast Guard Air Station at Elizabeth City, North Carolina. The aircraft operated from Canadian Forces Base, Summerside, Prince Edward Island, Canada throughout the season. Since Summerside is some 500 miles from the area of icebergs, it was the usual practice to top-off fuel at St. John's, Newfoundland on the outbound leg of the flight. Occasionally, when good visibility was forecast for two or more successive days the aircraft terminated its flight at St. John's and several thousands of air-miles were saved.

The honest welcome and cooperation given by the Canadian Forces at Summerside was deeply appreciated. They were generous and professional in providing logistic and communication support to the Ice Reconnaissance Detachment.

Table 1 - Aerial Ice Reconnaissance Statistics

September 1970 to August 1971

MONTH	Preseason No. Flts.	Preseason Flt. Hrs.	Season No. Flts.	Season Flt. Hrs.	Postseason No. Flts.	Postseason Flt. Hrs.	Total No. Flts.	Total Flt. Hrs.
SEP	3	13.4					3	13.4
OCT	4	22.9					4	36.3
NOV	0	0					0	0
DEC	0	0					0	0
JAN	4	20.7					4	20.7
FEB	3	19.2					3	19.2
MAR	3	20.7	8	60.8			11	81.5
APR			9	56.8			9	56.8
MAY			11	68.0			11	68.0
JUN			11	72.2			11	72.2
JUL					0	0	0	0
AUG					0	0	0	0
GRAND TOTALS	17	96.9	39	257.8	0	0	56	354.7

COMMUNICATIONS

Ice Patrol communications included ice, meteorological, and oceanographic data, Ice Bulletins, special ice advice, a daily facsimile chart, and the administrative and operational traffic necessary to the operation of the Patrol. The Ice Bulletin was transmitted by teletype from the Ice Patrol Office in New York twice each day to over 30 addressees, including those radio stations which broadcast the Bulletin. These radio stations were the U. S. Coast Guard Radio Station Boston/NIK/NMF, U. S. Naval Radio Station Washington/NSS, Canadian Coastal Radio Station St. John's/VON, and Canadian Forces Maritime Radio Station Mill Cove/CFH.

Coast Guard Radio Station Boston transmitted the Bulletin by CW at 0018 GMT on 5320 and 6502 kHz and at 1218 GMT on 8502 and 12750 kHz. Coastal Radio St. John's made CW broadcasts at 0000 and 1330 GMT on 478 kHz, while the stations at Mill Cove and Washington made their CW broadcasts on a wide range of low and high frequencies. An abbreviated form of the normal Bulletin was included in the twice daily voice transmission of the North Atlantic High Seas Broadcast which originated from Radio Boston. A daily radio facsimile broadcast, a service which was not available in 1970, was reinstituted on 10 March. A chart depicting the locations of icebergs and sea ice was broadcast at 1600 GMT simultaneously on 8502 and 12750 kHz at a drum speed of 120 revolutions per minute.

In a conscious effort to shorten the Bulletin's transmission time, the sentence, which requested ships between latitudes 40°N and 50°N and between longitudes 42°W and 60°W to report their position, course, speed, visibility, air temperature, sea surface temperature, and wind every six hours, was eliminated from the twice-daily Bulletin. Perhaps as a result, the number of these reports received from shipping fell to 159 from the total of 1014 received in 1970. During the Season 162 ice reports were received from shipping. There were 4 requests for special ice information.

ICE CONDITIONS, 1971 SEASON

September-December

During this period icebergs continued to drift south along the Labrador Coast. Icebergs were frequently reported along the Great Circle track to the Strait of Belle Isle from the coast eastward to 50-30W. Several grounded bergs were reported along the Newfoundland Coast from Cape Bauld to Cape Freels. The southernmost drifting iceberg was reported in early September at 50-55N 47-21W. Aircraft and ships reported icebergs south of Greenland to as far south as 56-06N, which is not unusual. New sea ice began to form along the entire Labrador Coast in December.

A preseason flight was flown between 27 September and 5 October over Baffin Bay and along the Canadian Coast from Cape Dyer to the Strait of Belle Isle. Figure 1 shows the distribution per one degree rectangle. Icebergs in bays and fiords were not counted.

Routine surveys of this nature are not planned in the future, nor does the International Ice Patrol plan to conduct preseason flights in December of each year as has been done since 1963 over the waters offshore from the Strait of Belle Isle to Cape Christian on northern Baffin Island. While these flights provided a valuable insight into the movement of icebergs in Baffin Bay and along the Canadian Coast, they have been of little value in the development of a capability to forecast the beginning and extent of the iceberg season on the Grand Banks.

January

No icebergs were reported from outside sources in January. On 13 and 14 January flights were made over the waters along the Canadian Coast from Hamilton Inlet to Cape Dyer. The result of these flights is shown in Figure 2, while Figure 3 depicts the anomalous count compared to the 1963-1970 average. At this time the sea ice extended south to the vicinity of Cape Freels, Newfoundland.

February

During the latter half of February icebergs were reported from 48-34N to 51-30N from the coast out to 47-15W. The southernmost iceberg was reported at 48-34N 47-15W on 25 February in open water. A growler was reported at 46-41N 47-16W on 24 February by the Coast Guard Cutter CHASE.

The February preseason flight was flown on 27 - 28 February and 4 March from 50-00N to Cape Chidley, Labrador. Flight results are contained in Figure 4 and they are compared with the 1963 - 1970 average in Figure 5. The iceberg count south of Hamilton Inlet was 181, which is considerably above the average of 63 icebergs. From Hamilton Inlet to Cape Chidley 335 icebergs were sighted; a number quite close to the average of 300 icebergs. At the end of the month the sea ice reached its maximum southern extent for the year as the southern ice edge lay from 47-10N 52-00W to 49-00N 49-00W.

March

The results of ice reconnaissance flights flown on 6, 7, and 9 March are depicted in Figure 6. During this period there was generally good visibility above 47-00N, while the visibility was quite poor to the south. The icebergs appeared to be in excellent position to move around the Grand Banks in the Labrador Current. However, subsequent March flights, which were conducted under poor conditions of visibility, sighted no icebergs south of 46-00N. Figure 7 displays ice reports received during the period 22 - 26 March. The southernmost iceberg of the month was sighted on 30 March at 46-15N 48-05W. Icebergs were also located well to the east of the core of the Labrador Current during the latter part of the month. Visual sightings and radar placed approximately six icebergs in the vicinity of Flemish Cap between 20 and 30 March. The easternmost berg was reported at 47-40N 43-47W on 27 March. During this period the sea surface temperature in the vicinity of Flemish Cap was 42°F (5.°C). It is estimated that 31 icebergs drifted south of 48-00N during the month. By the end of the month the sea ice had retreated to north of 50-00N.

The use of anomalous pressure patterns to predict or explain anomalous iceberg movement was discussed by Kelly and Morgan (1970). Using the same techniques of determining pressure gradients along lines which are parallel or perpendicular to the normal iceberg route, it is observed that the conditions during March were very unfavorable for southward iceberg drift and favorable for eastward drift. In this connection and noting the early appearance of icebergs and growlers south of 49-00N in February, it should be explained that the mean wind conditions during February were favorable for southward drift and slightly favorable for eastward movement.

April

The reconnaissance aircraft was unable to obtain a good series of flights along the eastern and southern edges of the Grand Banks during April due to frequent frontal passages and associated rain and fog. On only three flights was the visibility sufficient to obtain 75% coverage of the planned search area and two of these were over the area north of the Grand Banks. Visual effectiveness was approximately 20% on the remaining six flights. A flight on 7 April located 44 icebergs north of the Grand Banks with the greatest concentration lying from 49-30N to 50-00N between 47-30W and 51-00W. It is estimated that four icebergs drifted south of 48-00N during the month. The southernmost iceberg for the month was reported at 45-35N 48-45W on 15 April. The easternmost iceberg was sighted on 18 April at 48-35N 44-25W. It is estimated that one iceberg drifted east to 47-11N 41-32W on 4 April after being sighted on 21 March at 46-55N 45-25W. At the end of the month the majority of the icebergs were located north of 48-00N between 45-00W and 49-00W and the sea ice had retreated farther north to 51-00N. Figure 8 is a chartlet showing ice reports received and the results of aerial reconnaissance during the period 7 - 12 April.

May

Only once during May, on the 9th, was the Patrol able to obtain good aerial reconnaissance south of 47-30N. This flight observed no icebergs north or east of the 50-fathom contour of the Grand Banks. Flights to the north located a concentration of 47 bergs between 49-00N and 50-00N which extended from 51-00W to 52-00W on the 3rd. This group was relocated on the 11th in a less compact arrangement which extended from 48-30N to 50-00N and westward from 49-00N to the Newfoundland Coast. This large group was never resighted, but the drift computations and aircraft and ship radar reports indicate that the bergs in the eastern portion of this group drifted southeasterly until their remains were scattered within a 100-mile radius of Flemish Cap by the 26th. An estimated 20 bergs drifted south of 48-00N during the month. The southernmost sighting occurred on 31 May when a ship reported two icebergs at 46-17N 48-25W. The month's easternmost sighting was reported on 11 May at 48-20N 45-15W. It is estimated that this iceberg drifted east to 49-14N 42-09W before melting. The iceberg drift plot carried the month's southernmost berg to an estimated position of 45-50N 47-45W on 8 May. Winds during the month were unfavorable for southerly drift over the Grand Banks and Flemish Cap area.

Figures 10 and 12 describe the results of aerial reconnaissance and ship reports during the period 6 - 14 and 24 - 31 May, respectively. Figures 9 and 11 show the estimated ice situations on 1 and 15 May, respectively.

June

The month of June began with the two bergs reported on 31 May as the only known ice south of 48-00N. This situation continued until 21 June when 3 icebergs and a large number of radar targets were reported by a ship near 47-05N 51-30W. These bergs were not sighted by our aircraft while flying over this area on 19 June nor were they relocated by aerial reconnaissance over this area on 24 and 26 June and they were presumed melted on the 27th. By 29 June, when Ice Patrol services for the season were terminated, the estimated limit of all known ice had retreated to the northwest. The limits in the final Bulletin were reported as extending from the Newfoundland Coast at 48-10N to 48-10N 46-30W to 48-30N 46-30W and then northwestward. It is estimated that only seven icebergs drifted south of 48-00N during June. Figure 13 depicts the results of reconnaissance and ship sightings during the period 14 - 21 June.

July

A drift plot of all the icebergs which were on plot when the 1971 Season ended was continued through 16 July when all were judged to have melted. It is estimated that 11 bergs drifted south of 48-00N during the month only to melt before crossing 47-00N. Several icebergs were sighted along the 48th parallel in early July. Throughout the month icebergs were reported in the eastern approaches to the Strait of Belle Isle from the coast eastward to the 100-fathom contour.

August

During August ships continued to report icebergs in the eastern approaches to the Strait of Belle Isle. The majority of these reports were west of the 1000-fathom contour and the frequency of reports tapered off rapidly after the 12th. The easternmost berg of the month was reported in position 54-27N 47-42W on the 9th. The southernmost reported berg was sighted in the vicinity of Funk Island. It is estimated that no icebergs drifted south of 48-00N during August 1971.

Table 2 - Estimated Number of Icebergs South of Latitude 48°N, Season of 1971

Season	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
1971	0	0	0	0	0	0	31	4	20	7	11	0	73
Average 1900-1945	5	2	2	2	3	10	46	105	154	76	26	8	440
Total 1946-1971	5	2	4	5	10	87	576	1850	1539	1068	246	12	5404
Average 1946-1971	0	0	0	0	0	3	22	71	59	41	9	0	208
Total 1900-1971	251	109	110	85	130	538	2678	6695	8622	4586	1442	401	25647
Average 1900-1971	3	2	2	1	2	7	37	93	120	64	20	6	356

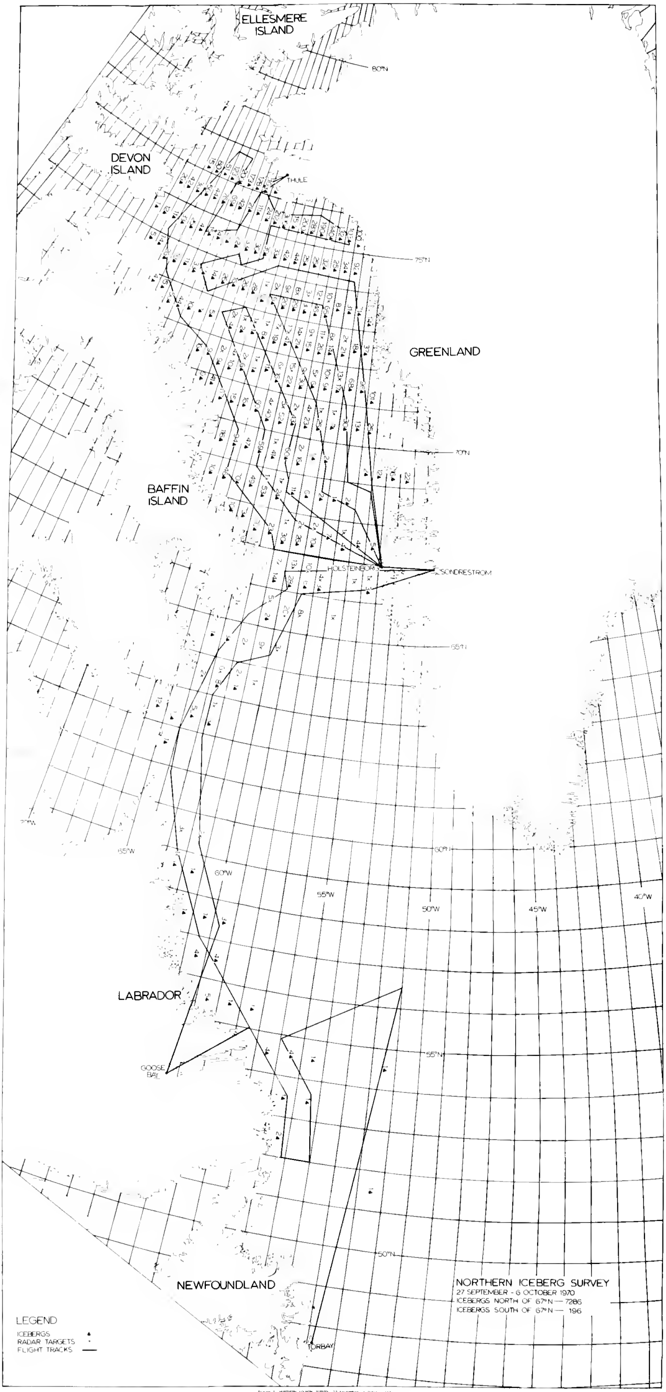


Figure 1 NORTHERN ICEBERG SURVEY, 27 September - 6 October 1970

Long Term Trends in the Iceberg Threat in the Northwest Atlantic

Abstract

Analysis of records on icebergs drifting past Newfoundland since 1880 reveals that the seasonal count of icebergs has fallen by 55% in the last three decades. An analysis of available environmental data for the same period shows that the decrease is associated with a decrease in the strength of winter northwesterly winds off southern Labrador and with an increase in winter air temperatures at Torbay, Newfoundland.

Introduction

Each year in the spring icebergs drift south in the Labrador Current along the Labrador coast. Many pass Newfoundland and are carried along the eastern slopes of the Grand Banks where they become serious hazards to ships (Figure 1). Smith (1931), drawing on his own observations and the earlier work of Schott (1904), Mecking (1907), and others, gives an excellent account of the origin, drift, distribution, and eventual disintegration of icebergs.

The number of icebergs which drift south of Newfoundland each year is highly variable, ranging from one or two to over a thousand. Mecking (1907) compiled a record of iceberg counts for the period 1880-1899. Smith (1931) extended this compilation to 1929. Since 1929 the annual Report of the International Ice Patrol Service in the North Atlantic has contained iceberg statistics. This record stretching back in time for 90 years is of interest because it reflects meteorological, oceanographic, and glaciological conditions since the 1880's. However, its validity should be tested by comparison with the record of another environmental parameter which is related to the iceberg count to see if the iceberg record appears consistent.

Internal Consistency of the Iceberg Record

Traditionally the intensity of the iceberg season is measured by the number of icebergs drifting south of 48°N. This is because 48°N represents the approximate northern boundary of trans-Atlantic shipping routes passing south of Newfoundland. Although icebergs can be found south of 48°N in all months of the year, an average of 93% are found during March-July, and these months are considered the iceberg season.

In analyzing the internal consistency of the iceberg record, it is of interest to understand how the various sections of the record were collected. The original compilation made by Mecking for 1880-1899 was of iceberg sighting reports. Because of duplicate sightings Mecking's counts commonly show several thousand iceberg sightings each year. Smith, in contrast, tried to eliminate duplicate reports, and his counts for the years 1900-1929 represent the actual number of icebergs which drifted past 48°N. Smith, through comparison of the two compilations with associated winter surface atmospheric pressure patterns, was able to establish a correspondence between the two different compilations, and published a summary table of iceberg intensity on a scale of 0-10 for the period 1880-1929 (Smith, Unpublished notes)(Smith, 1931). After 1929, although the data were collected and analyzed by different persons, it probably was done rather uniformly until 1942. During 1943-1945 the International Ice Patrol was suspended, and iceberg counts were based on the reports of convoys and military air patrols. It is believed that the counts for these years are too high (Schell, 1962). When the International Ice Patrol recommenced after the war, regular aerial ice patrols replaced ship reports as the primary means of collecting ice information. Because of the relative regularity and more systematic coverage of aerial reconnaissance, the data collected since 1946 is undoubtedly the most accurate.

The iceberg counts used in this paper are given in Table 1, and were based on data presented by Smith (1931), Murray (1969), and Kelly and Morgan (1970).

The environmental parameter used in evaluating the internal consistency of the iceberg record is the December-March atmospheric pressure difference between Belle Isle, Newfoundland and Ivigtut, Greenland. This pressure difference is an indicator of the strength of northwesterly winds along the southern Labrador coast since the pressure gradient it measures is approximately normal to the Labrador coast in a northeasterly direction. Many authors (Mecking, 1907; Smith, 1931; Soule and Challender, 1949; Schell, 1962) emphasize the relationship between the strength of northwesterly winter winds and the drift of icebergs south toward the Grand Banks. Smith (1931) and Schell (1952,1962) made use of Newfoundland/Greenland pressure differences in deriving iceberg prediction formulas. Assuming then that a relationship exists between iceberg intensity and the Belle Isle/Ivigtut pressure difference, if the iceberg data have been collected with relatively uniform accuracy there should be no substantial difference in the iceberg/pressure difference relationship when it is derived for various periods between 1880 and 1969. Such a derivation is made for the periods 1880-1903, 1919-1942, and 1946-1969. These three periods more or less cover the periods of Mecking's data, Smith and pre-aerial patrol data, and aerial patrol data.

Figure 2-January 1971 Iceberg Concentration

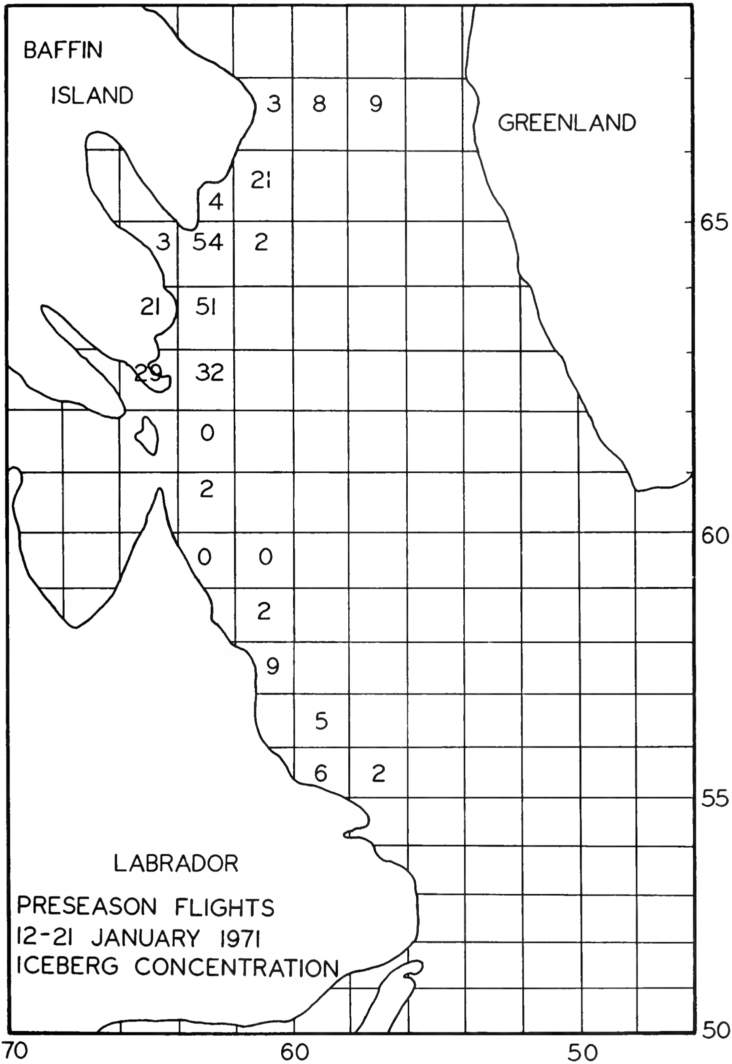


Figure 3-January 1971 Anomoly

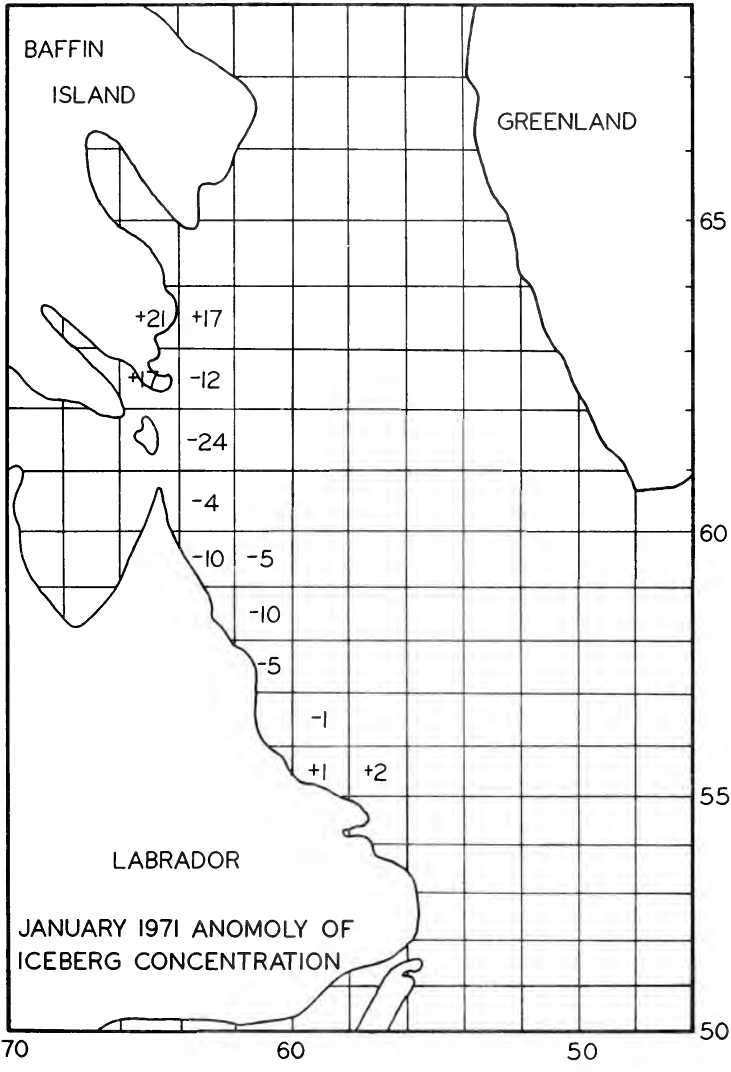


Figure 4-February 1971 Iceberg Concentration

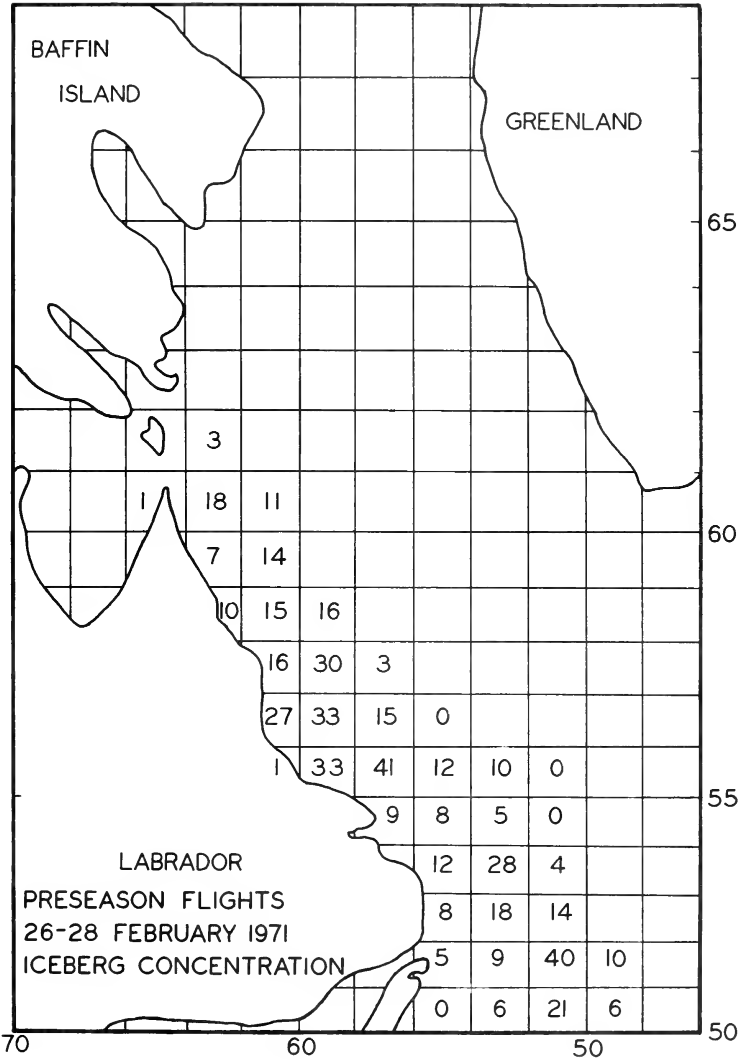
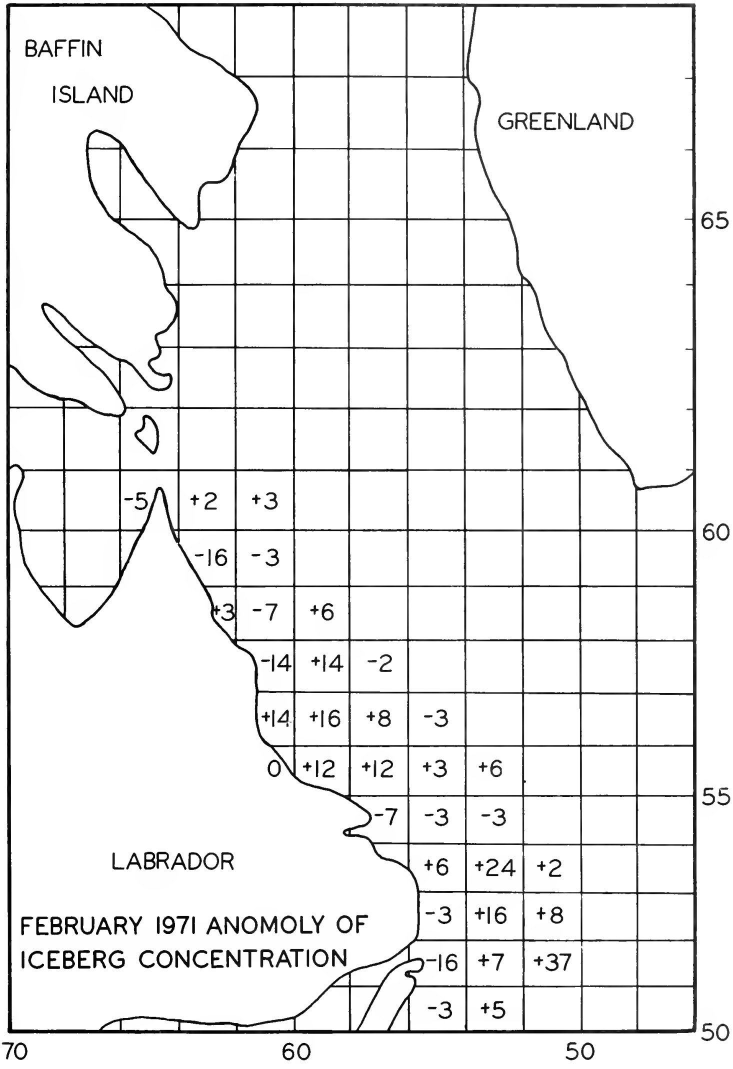


Figure 5-February 1971 Anomoly



The regression line relating iceberg count as dependent variable to December-March Belle Isle/Ivigtut pressure difference as independent variable is shown in Figure 2 for the three periods selected. There is no substantial difference in the slope of the regression line for the three periods, however it is observed that Smith in recompiling Mecking's data possibly introduced bias through considering the December-March Belle Isle/Ivigtut pressure difference to some extent which cannot now be exactly reconstructed. Assuming that the 1946-1969 data are most correct, then the 1880-1903 relationship is high by about 66 icebergs or 19%, and the 1919-1942 relationship is high by about 42 icebergs or 11%. It is concluded that, in terms of average values over about twenty years, differences in iceberg count of more than those shown in Table 2 are probably significant.

Frequency Distribution of Iceberg Counts

Smith (1931) states that iceberg count data fail to follow the requirement that a normally distributed variable show the greatest number of deviations proportionately near the mean. In order to correct this he arranged the data in conformity with the shape of a normal probability curve, and from this constructed a transform curve to convert from actual iceberg counts to normally distributed counts on a scale of 0-10. Smith (1931) and Schell (1952, 1962) made use of normally distributed iceberg data on a scale of 0-10 in deriving their iceberg prediction formulas. Figure 3 shows the frequency distribution of iceberg count data. The distribution is clearly not normal. Low count data are most frequent, with frequency falling off rapidly with increasing count. There are indications of a second frequency mode at 200-400. About 30% of the years since 1880 have seen less than 100 icebergs even though the average count since 1880 is 337 icebergs. In about 50% of the years since 1946 the count has been less than 100 even though the average since then is 222. Thus a normal distribution centered on the average fails to emphasize the fact that iceberg intensity is most commonly very light.

Long Term Trends in the Iceberg Threat to the Northwest Atlantic

In order to analyze the long term trend of the iceberg threat, nineteen year running average iceberg counts were computed for the years 1889-1960. The effect of the nineteen year running average is to remove short term variations in the iceberg record. The choice of 19 years for the period of the running averages was arbitrary; it being desired to show trends which were only significant over periods of about twenty years since that was the approximate periods of the data series in Table 2. The nineteen year running average of iceberg counts is shown in Figure 4. There appear to be three phases in the data. The first phase, extending from 1889 to the early 1920's, was a more or less stable period with average counts running between 325 and 440. The second phase, from the early 1920's to about 1937, was a period when the average number of icebergs was rising to almost 500. During the third phase subsequent to about 1937 the average iceberg count has fallen sharply and almost continously to reach a low of about 200 as of 1960. Comparison of the stable, rising, and declining phases with the criteria in Table 2 indicates that the differences in the three phases are probably significant. Assuming that the trends in Figure 4 are significant, then the average iceberg danger at present is about half of what it was at the time of the sinking of the Titanic in 1912, and is about 45% of what it was in 1937.

Factors Associated with Iceberg Trends

The purpose of this paper is simply to present the long term trend of iceberg statistics. The purpose is not, at this time, to explain the causes of these trends. Presented below is information on long term trends of environmental data that might be expected to be associated with long term iceberg trends. The fact that the data correlates is merely to be interpreted that the iceberg statistics are probably valid. The choice of environmental data is severely limited to that which is available back to 1880.

Soule, et al (1950) indicate that the three most important factors affecting the iceberg threat are 1) the supply of icebergs available, 2) the efficiency of iceberg transport to the northwest Atlantic, and 3) iceberg mortality during the drift south. The complexity of these factors is increased because they are interrelated and act over a path of about 1800 miles and possibly several years duration.

In the case of the iceberg supply factor it is difficult to find environmental data that is both intuitively reasonable and available. Direct iceberg counts in Baffin Bay have been made only a few times since 1880, and are thus not available. Smith (1931) suggested a relationship between summer air temperatures at Upernavik, Greenland and iceberg supply. It is not unreasonable to suspect that increased air temperatures at Upernavik might be related to a decrease in iceberg supply through melting.

In the case of efficiency of iceberg transport, the Belle Isle/ Ivigtut pressure difference as a measure of the strength of northwesterly winds has already been described. This pressure difference is probably also associated with the strength of the Labrador Current.

In the case of iceberg mortality during the drift south, Groissmayr (1939) found that the December-February air temperature at St. Johns, Newfoundland correlated with iceberg intensity. It is reasonable to infer that this correlation was related to increased melting caused by either the higher air temperatures or higher water temperatures associated with the higher air temperatures. It should be mentioned that to some degree this correlation must also be attributed to the fact that warmer air temperatures are related to a decrease in northwesterly winds which carry icebergs south.

To investigate the possible iceberg supply, efficiency of transport, and mortality since 1880, the 19 year running average for each of the following was computed and is shown in Figure 4: June-September Upernavik air temperature, December-March Belle Isle/Ivigtut pressure difference, and December-March Torbay, Newfoundland air temperature. The record at Torbay is actually a combination of Torbay and nearby St. Johns. The record at Torbay began in 1946, and the record at St. Johns ended in 1956. A correction which was constant within ±0.1°C in 75% of the cases during the period of overlapping record was applied to the St. Johns data to convert it to Torbay data.

Considering the overall trend of the 19 year running average of temperatures at Upernavik, the temperature in the 1950's is about 0.7°C warmer than in the 1890's, however the details of the Upernavik record are difficult to relate to the iceberg record; there are warming peaks soon after the turn of the century and in the mid-1930's which appear to positively correlate about 7 years later with increasing iceberg intensity on the Grand Banks. Although the Upernavik temperature record does not seem to support the validity of the iceberg statistics, it is of interest that if the iceberg record lags the Upernavik temperature record by about 2 decades, they do seem to correlate inversely as postulated.

The trend of the 19 year running average Belle Isle/Ivigtut pressure difference is in general agreement with the trend of average iceberg counts, thus indicating that the iceberg record is valid. There is an initial period of moderate pressure differences followed by a rise in the 1920's which reached a peak of 9 millibars in the late 1920's, about 6 or 7 years before the iceberg intensity peak. The decline in the average pressure difference since 1929 has been almost uninterrupted.

The 19 year running average air temperature at Torbay has, as expected, varied more or less inversely with the iceberg count. After a low of about -5°C in the early 1920's, about 18 years before the iceberg maximum, the average has climbed steadily, reaching about -2.7°C by the late 1950's. The air temperatures at Torbay also correlate inversely with the Belle Isle/Ivigtut pressure difference, as expected.

Conclusions

The evidence indicates that there has been a significant decrease in the severity of the iceberg threat to the northwest Atlantic since the 1880's. This decrease is apparently substantiated by a trend toward winds less favorable for the drift of icebergs along the Labrador and Newfoundland coasts, and by an increase in air temperature along the Newfoundland coast.

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Table 1

Number of Icebergs Drifting South of 48°N, March-July

Year	Count	Year	Count	Year	Count	Year	Count	Year	Count
1880	367	1898	414	1916	54	1934	574	1952	14
81	33	99	451	17	38	35	869	53	56
82	549	1900	76	18	125	36	22	54	295
83	367	01	68	19	187	37	397	55	61
84	600	02	36	20	340	38	659	56	80
85	772	03	792	21	679	39	844	57	879
86	237	04	260	22	455	40	1	58	1
87	405	05	800	23	228	41	2	59	689
88	302	06	364	24	8	42	30	60	250
89	149	07	623	25	106	43	833	61	107
90	959	08	181	26	330	44	699	62	120
91	93	09	904	27	372	45	1062	63	25
92	237	10	50	28	502	46	428	64	365
93	321	11	323	29	1320	47	59	65	75
94	549	12	996	30	342	48	523	66	0
95	79	13	523	31	13	49	47	67	441
96	195	14	571	32	513	50	444	68	222
97	549	15	359	33	214	51	2	69	53

Table 2

Significant Differences in Iceberg Data

Periods from which Data is being Compared	Difference is probably Significant if more than (over a twenty year average)
1880-1903 and 1946-1969	66 icebergs
1880-1903 and 1919-1942	24 icebergs
1919-1942 and 1946-1969	42 icebergs

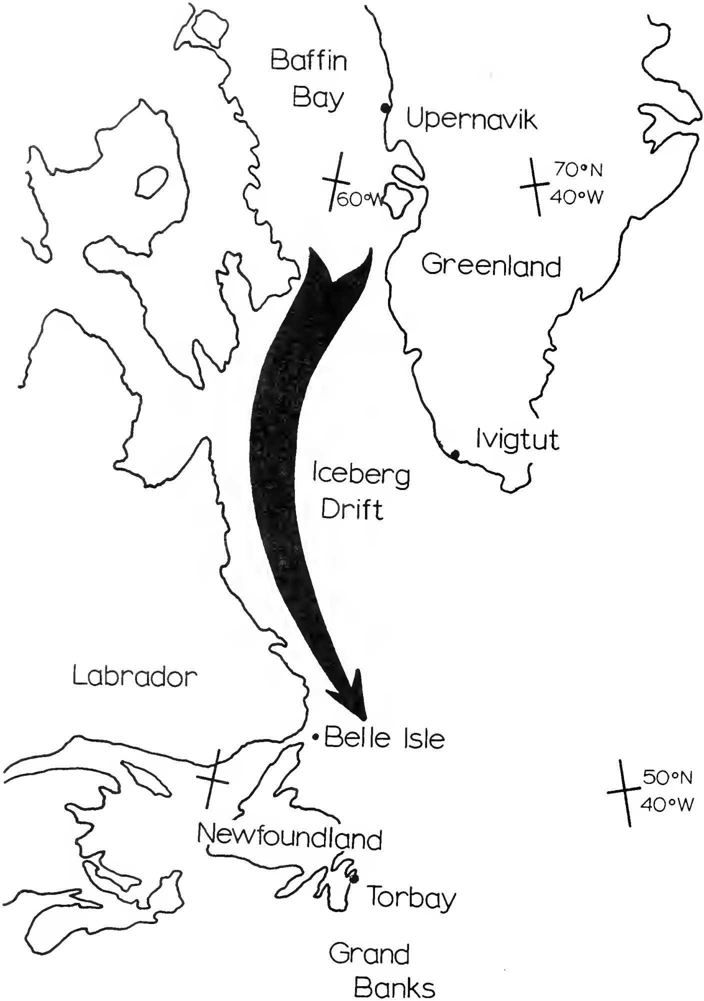
Baffin
Bay
Upernavik
70°N
40°W
60°W
Greenland
Ivigtut
Iceberg
Drift
Labrador
Belle Isle
50°N
40°W
Newfoundland
Torbay
Grand
Banks

Figure 1

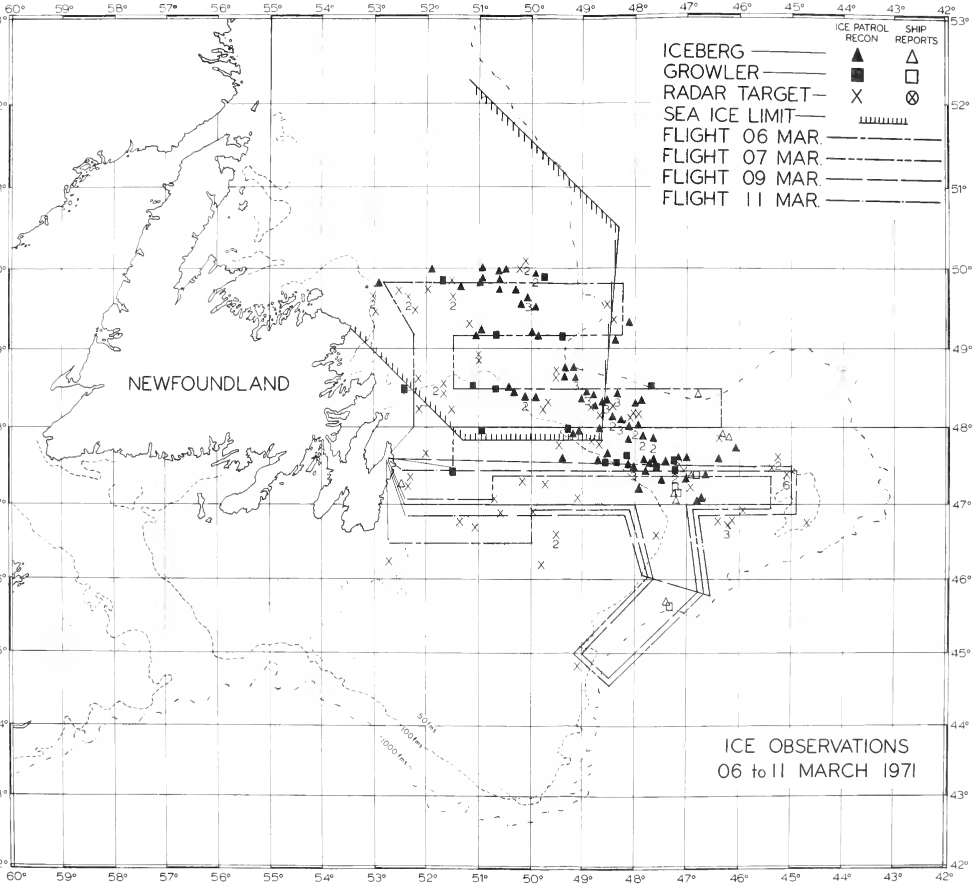

Figure 6-Ice Observations, 6-11 March 1971

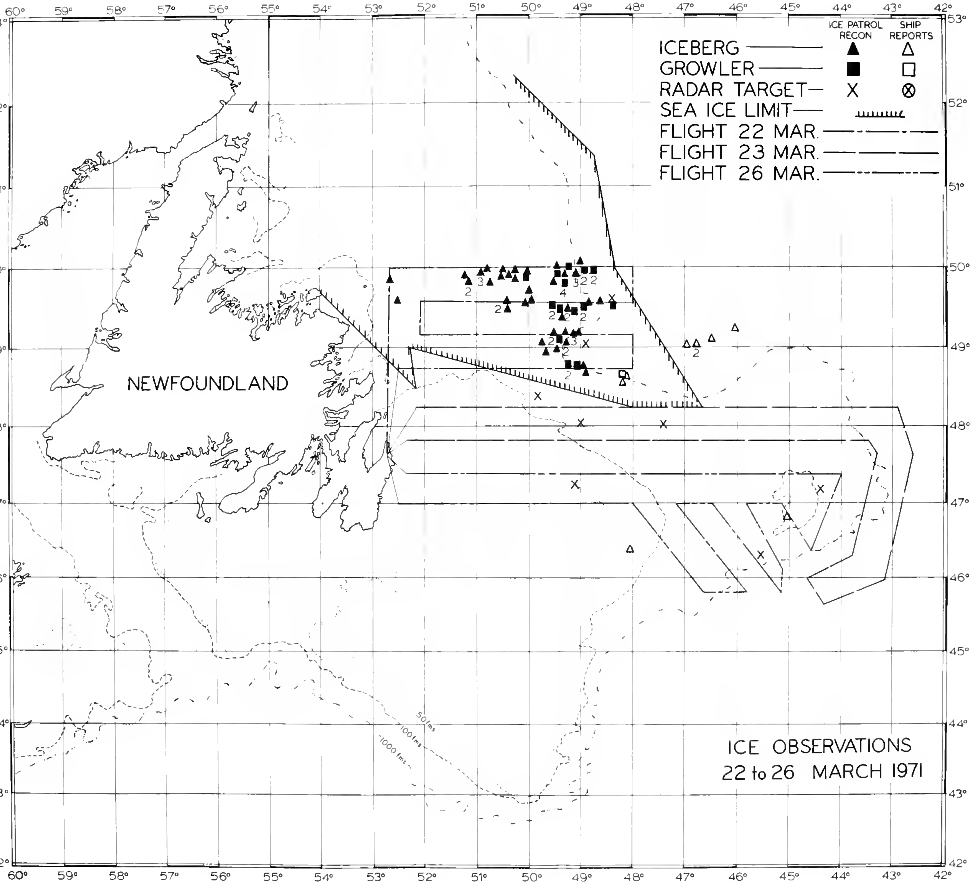

Figure 7-Ice Observations, 22-26 March 1971

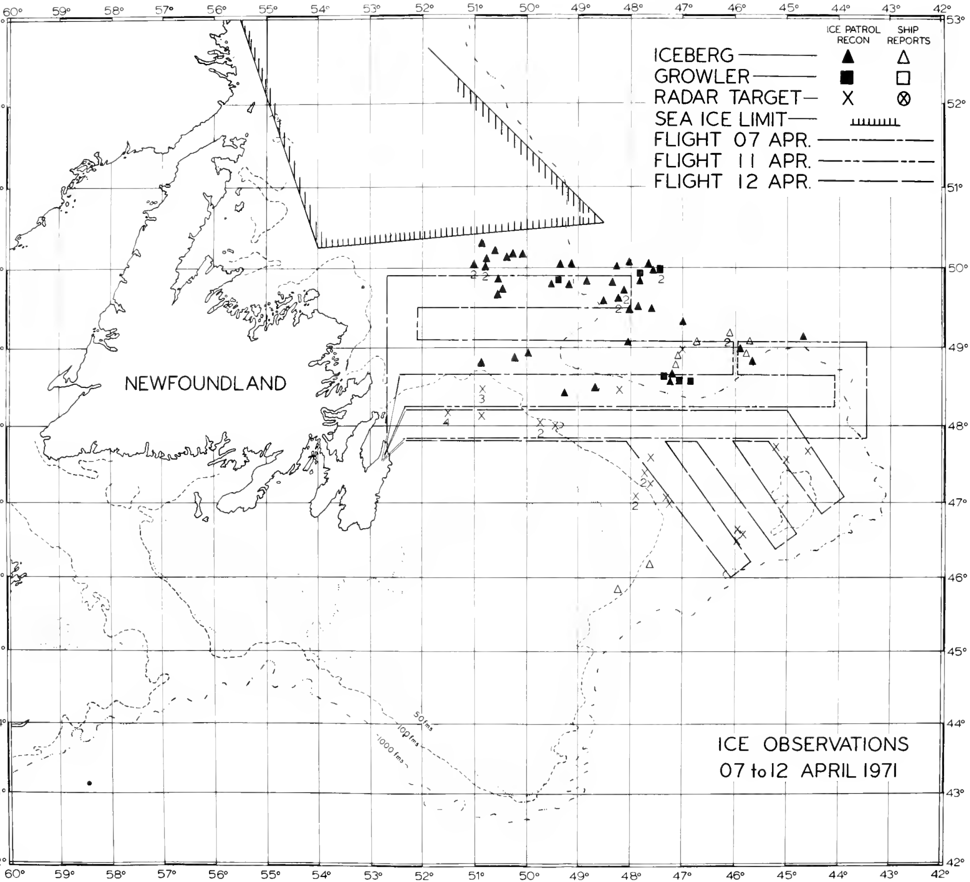

Figure 8-Ice Observations, 7-12 April 1971

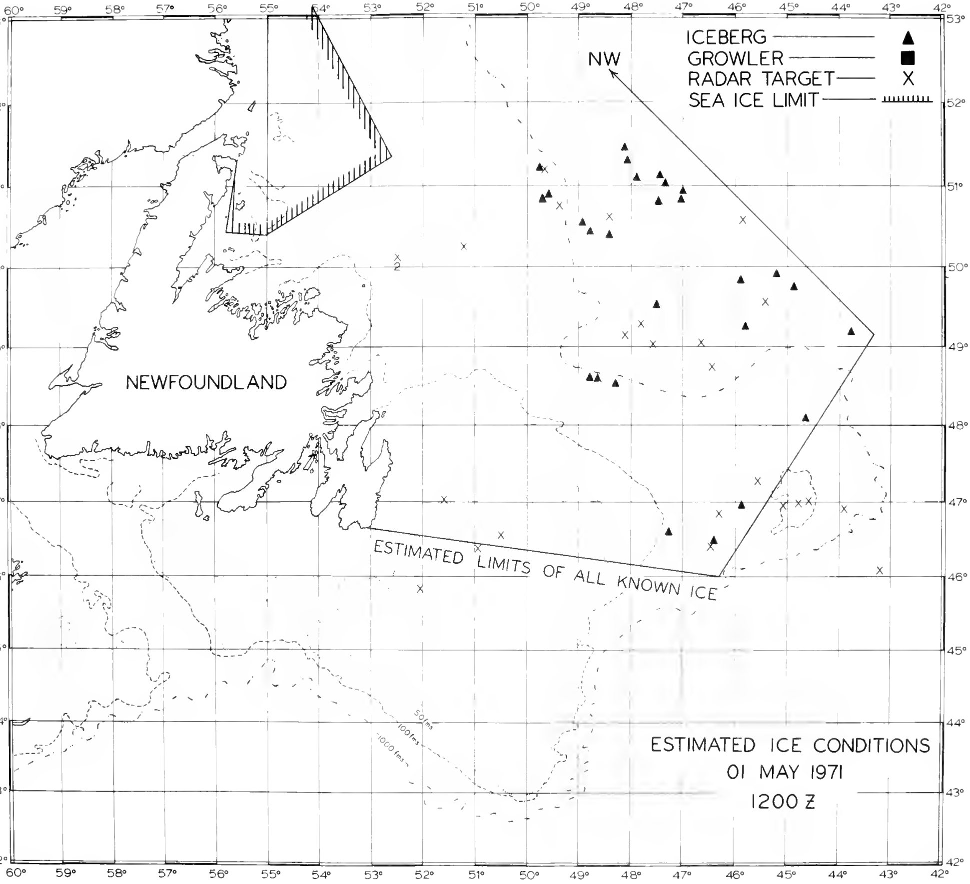

Figure 9-Estimated Ice Conditions, 1 May 1971

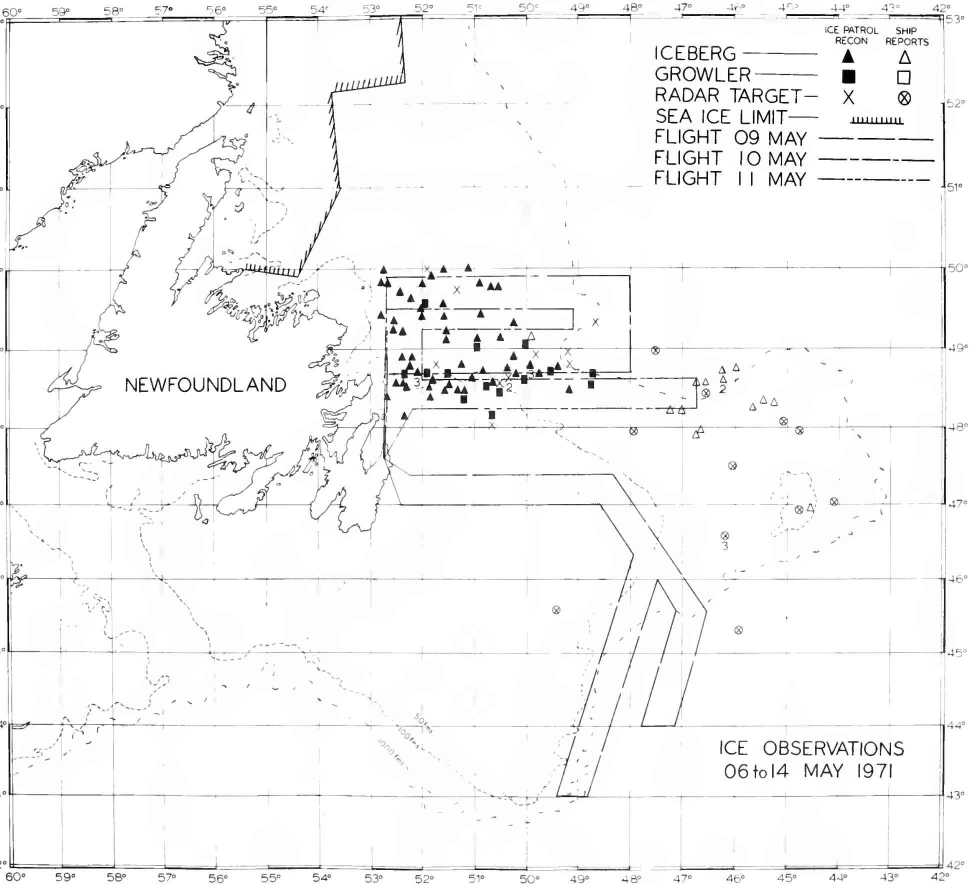

Figure 10-Ice Observations, 6-14 May 1971

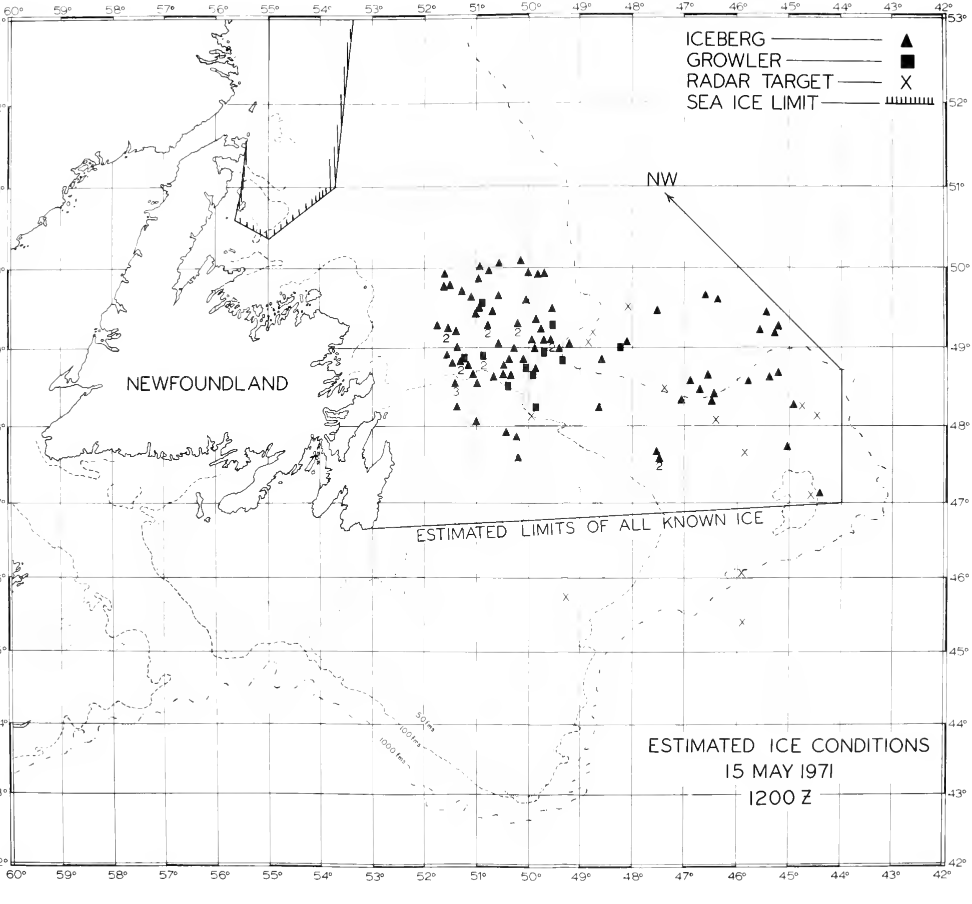

Figure 11-Estimated Ice Conditions, 15 May 1971

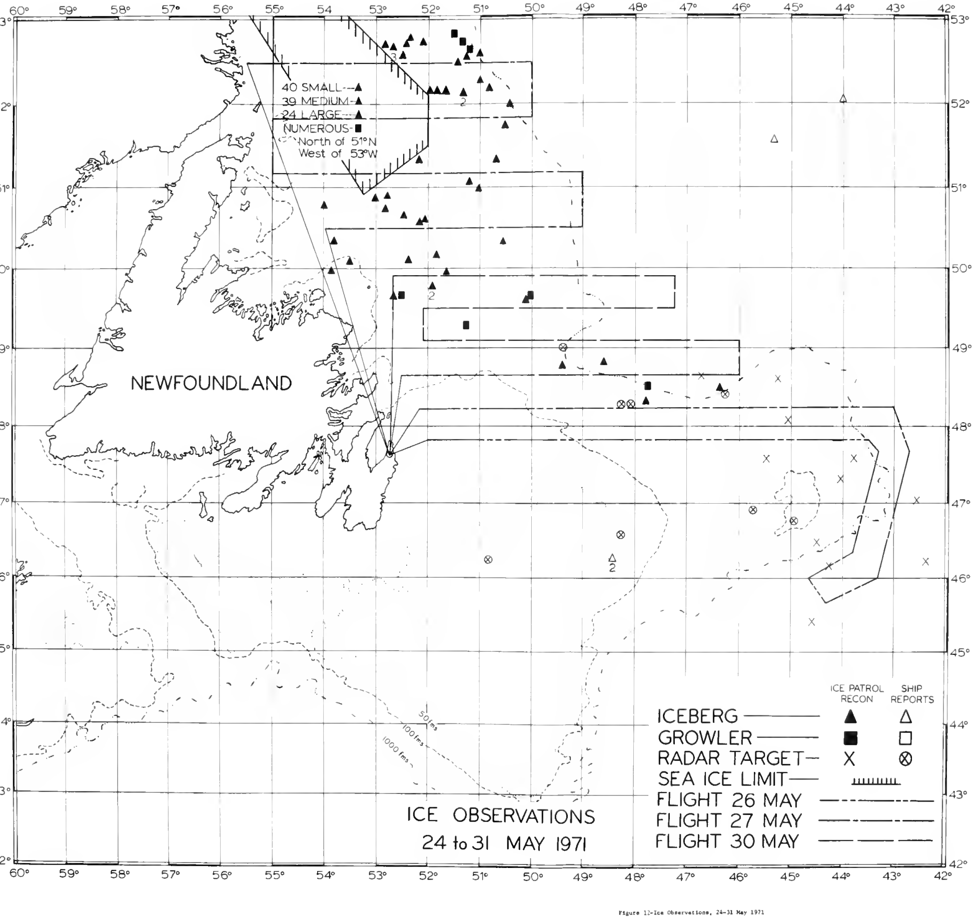

Figure 12-Ice Observations, 24-31 May 1971

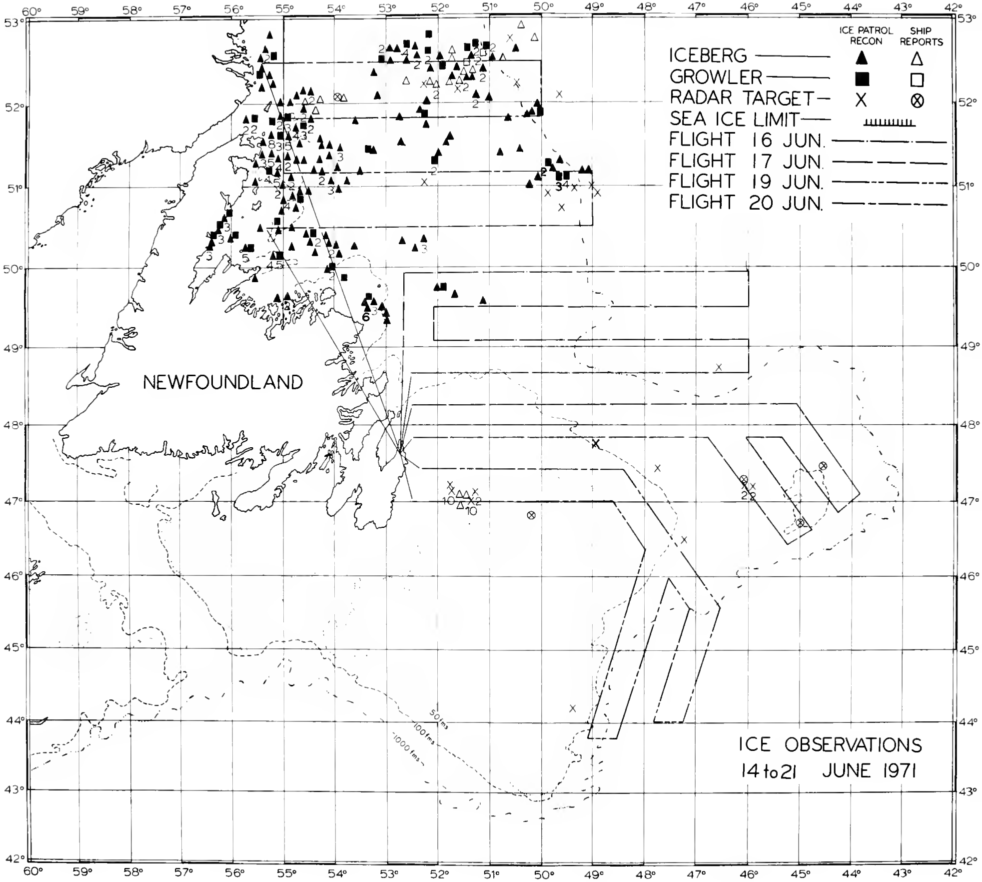

Figure 13-Ice Observations, 14-21 June 1971

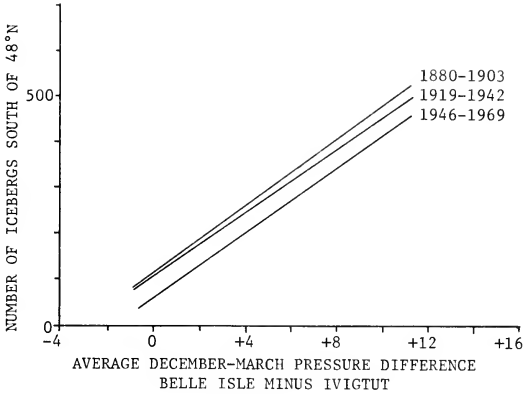

Figure 2

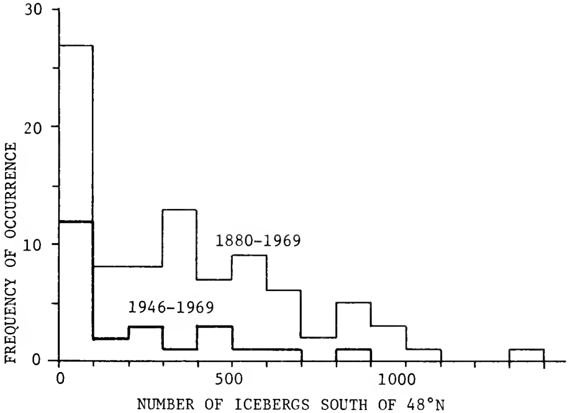

Figure 3

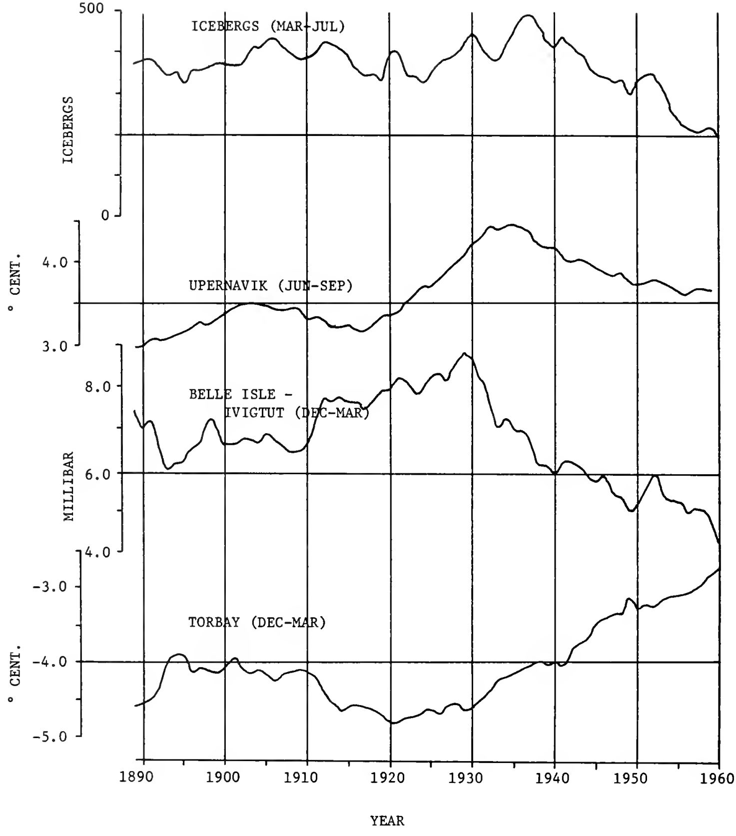

Figure 4

U. S. GOVERNMENT PRINTING OFFICE : 1974 O - 532-522

DEPARTMENT OF TRANSPORTATION

COAST GUARD

BULLETIN NO. 58

Report of the International Ice Patrol Service in the North Atlantic Ocean

SEASON OF 1972

CG-188-27

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UNITED STATES COAST GUARD

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Bulletin No. 58

REPORT OF THE INTERNATIONAL ICE PATROL SERVICE IN THE NORTH ATLANTIC OCEAN

Season of 1972

CG-188-27

FOREWORD

Forwarded herewith is Bulletin No. 58 of the International Ice Patrol describing the Patrol's services, and ice observations and conditions during the 1972 season.

W. A. JENKINS
Chief, Office of Operations

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TABLE OF CONTENTS

PREFACE

This report is 58th in a series of annual reports on the International Ice Patrol Service in the North Atlantic Ocean. It contains information on Ice Patrol organization, communications and operations, on ice and environmental conditions and their relationship in 1972, and on the dynamic topography surveys conducted during April, May and June 1972.

The author of this report, LT Douglas W. CROWELL, USCG acknowledges ice and weather data supplied by the Canadian Department of Transport, weather data supplied by the U.S. National Weather Service, weather and oceanographic data supplied by the U.S. Coast Guard Oceanographic Unit. Acknowledgement is also made to Yeoman First Class Bruce S. COLLINS, USCG, Senior Chief Marine Science Technician Paul R. FLOWERS, USCG, Marine Science Technician First Class James A. SHAFER, USCG, Marine Science Technician Second Class Joseph C. DELWICHE, USCG, Marine Science Technician Third Class Larry D. STARK, USCG, and Marine Science Technician Third Class James M. GAYNOR, USCG for assistance in the preparation of the manuscript and illustrations for this report.

In January 1972, FINLAND became the eighteenth nation to sponsor the International Ice Patrol joining Belgium, Canada, Denmark, France, Germany, Great Britain, Greece, Israel, Italy, Japan, Liberia, Netherlands, Norway, Panama, Spain, Sweden, United States of America, and Yugoslavia.

The generosity and cooperation given by the Canadian Forces in permitting the International Ice Patrol to operate from their base at Summerside is gratefully acknowledged.

INTERNATIONAL ICE PATROL 1972

The 1972 International Ice Patrol Service in the North Atlantic Ocean was conducted by the U.S. Coast Guard under the provisions of Title 46, United States Code, Sections 738, 738a through 738d, and the International Convention for the Safety of Life at Sea, 1960, Regulations 5 through 8. The International Ice Patrol is a service for observing and disseminating information on ice conditions in the North Atlantic. During the ice season, the southeastern, southern and southwestern limits of the regions of icebergs in the vicinity of the Grand Banks of Newfoundland are guarded for the purpose of informing passing ships of the extent of this dangerous region. The International Ice Patrol also studies ice conditions in general, and affords assistance to ships and crews requiring aid within the limits of operation of Ice Patrol forces.

The International Ice Patrol was directed from the Ice Patrol Office located on U.S. Coast Guard Base, Governors Island, New York. The Ice Patrol Office gathers ice and other environmental reports from various sources, maintains an ice plot, forecasts ice conditions, prepares the Ice Bulletin, and maintains operational control of the Ice Reconnaissance Detachment, the Ice Patrol oceanographic cutter and the Surface Patrol cutter when assigned.

Vice Admiral Benjamin F. ENGEL, USCG, was Commander, International Ice Patrol. Captain Eugene A. DELANEY, USCG, was directly responsible for the management of the Patrol.

Preseason Ice Patrol flights were made in January and February, 1972. The Ice Reconnaissance Detachment deployed to Canadian Forces Base Summerside, Prince Edward Island, on 28 February and returned to the United States on 2 September.

The 1972 ice season officially commenced at 0000 GMT 29 February when the first Ice Bulletin was issued, and continued until 4 September. The twice daily Ice Bulletin was broadcast by International Ice Patrol Radio Station Boston/NIK, U.S. Naval Radio Station Washington/NSS, Canadian Maritime Command Radio Station Mill Cove/CFH, and Canadian Coastal Radio Station St. John's/VON. Radio Station Boston included the Ice Bulletin on the Western North Atlantic High Seas Broadcast eight times daily and broadcast an ice radiofacsimile chart once a day throughout the ice season.

The USCGC EVERGREEN, commanded by Lieutenant Commander William MONSON, USCG, conducted oceanographic cruises for the Ice Patrol during the periods 3 - 23 April, 5 - 21 May and 3 - 22 June. The EVERGREEN also served as Surface Patrol Cutter during the June oceanographic cruise.

For the first time since 1959 a surface patrol was initiated. On 25 April USCGC DUANE commanded by Commander Robert B. BACON, USCG, left Ocean Station DELTA and assumed duties as Surface Patrol cutter on 26 April. The following 210-class medium endurance cutters and the oceanographic cutter conducted the surface patrol during the periods indicated:

USCGC VIGOROUS	commanded by Commander James J. ROONEY III	2 - 14 MAY
USCGC DECISIVE	commanded by Commander Robert J. DESCOTEAUX	14 - 25 MAY
USCGC VALIANT	commanded by Commander Billy C. READ	25 MAY - 7 JUN; 15 - 24 JUN
USCGC EVERGREEN	commanded by Lieutenant Commander William A. MONSON	7 - 15 JUN
USCGC VIGOROUS	commanded by Commander Richard W. MICHAELS	24 JUN - 2 JUL
USCGC VIGILANT	commanded by Commander Edward R. BAUMGARTNER	2 - 17 JUL
USCGC ALERT	commanded by Commander Robert C. NICHOLS	17 - 25 JUL

On 25 July, with icebergs no longer a threat below 43°N, the surface patrol was terminated.

During the 1972 season an estimated 1587 icebergs drifted south of 48°N, the heaviest and longest season in the Ice Patrol 60-year history.

AERIAL ICE RECONNAISSANCE

During the period 1 September 1971 to 4 September 1972, a total of 82 ice observation flights were made. Preseason flights made in January and February accounted for 7 flights, and 75 flights made during the season accounted for the remainder. The purpose of the preseason flights was to study iceberg distribution patterns in the Labrador Sea and to evaluate the iceberg potential of the developing ice season. The purpose of the flights during the season was to guard the southeastern, southern, and southwestern limits of icebergs, to evaluate the short term iceberg potential of the waters immediately north of the Grand Banks, and occasionally to study the iceberg distribution along the Labrador coast. Flight statistics are shown in Table 1, and are exclusive of time required to deploy from U.S. Coast Guard Air Station, Elizabeth City, North Carolina, to the operating base.

Table 1. AERIAL ICE RECONNAISSANCE STATISTICS
SEPTEMBER 1971 TO AUGUST 1972

Month	Number of Flights	Flight Hours
PRESEASON		
Sep-Dec	0	0
January	3	26.6
February	4	39.1
Preseason total	7	65.7
SEASON		
March	9	68.0
April	15	120.3
May	19	132.4
June	8	45.9
July	14	92.4
August	9	58.6
September	1	8.0
Season total	75	525.6
Annual total	82	591.3

Aerial ice reconnaissance was accomplished by U.S. Coast Guard Lockheed HC130B aircraft from the U.S. Coast Guard Air Station at Elizabeth City, North Carolina. During the preseason flights the aircraft operated from U.S. Air Force Base Goose Bay, Labrador; U.S. Air Force Base Sondrestrom, Greenland; Canadian Forces Base Summerside, Prince Edward Island; and Torbay Airport St. John's, Newfoundland. During the iceberg season the aircraft operated out of Canadian Forces Base Summerside, Prince Edward Island; Torbay Airport St. John's, Newfoundland; and Gander Airport, Newfoundland.

On 28 February the Ice Reconnaissance Detachment deployed to Summerside from Elizabeth City. Occasionally, during periods of good visibility, the aircraft operated from St. John's due to its close proximity to the Grand Banks. The main base remained at Summerside until 2 September when the Detachment returned to the United States. Twice during the season, during 21-25 May and 16-19 June, it was necessary to deploy two C-130 aircraft to take advantage of forecast improvement in on scene weather conditions. A C-130 was not deployed 4-7 August, 20-23 August and 25-30 August due to poor weather present over the area and no forecast for improvement for at least several days.

COMMUNICATIONS

Ice Patrol communications included receiving reports of ice and environmental conditions, and transmitting ice bulletins, voice broadcasts, facsimile charts, and administrative traffic necessary to operate the patrol. The Ice Bulletins were disseminated by teletype from the Ice Patrol office in New York to over 30 addresses.

International Ice Patrol Ice Bulletins were broadcast twice daily by Coast Guard Radio Station Boston/NMF/NIK at 0018 GMT on 5320 and 8502 KHz, and at 1218 GMT on 8502 and 12750 KHz. After a 2-minute series of test signals the transmissions were made at 25 words per minute and then repeated at 15 words per minute. An abbreviated version of the Ice Bulletin was included in the Western North Atlantic High Seas Broadcast from Radio Boston/NMF on 8765.4 (8764.0) KHz upper side band mode at 0130, 0730, 1330 and 1930 GMT and on 8764.0 KHz double side band mode at 0200, 0800, 1400 and 2000 GMT. Coast Guard Radio Station Boston/NIK also transmitted a daily radiofacsimile broadcast on 8502 and 12750 KHz (drum speed 120) at 1600 GMT.

Ice Bulletins were also broadcast twice daily by U.S. Naval Radio Station Washington/NSS at 0430 and 1700 GMT on 88.0 (0430 only), 185.0, 5870, 8090, 12135 and 16180 KHz; Canadian Maritime Command Radio Station Mill Cove/CFH at 0130 and 1330 GMT on 4356.5, 6449.5, 12984, 7218.4 and 22587 KHz; and Canadian Coastal Radio Station St. John's/VON at 0000 and 1330 GMT on 478 KHz.

Special broadcasts were made by Canadian Coastal Radio Station St. John's/VON as required when icebergs were sighted outside the limits of ice between regularly scheduled broadcasts. These transmissions were preceded by the International Safety Signal (TTT) on 500 KHz.

Merchant ships calling to transmit ice sightings, weather and sea surface temperatures were requested to use the regularly assigned international call signs of the Coast Guard Ocean Stations, East Coast AMVER Radio Stations, or Canadian Coastal Radio Station, St. John's. Coast Guard Stations were alert to answer NIK/NIDK calls, if used.

Ice information services for the Gulf of St. Lawrence, as well as the approaches and coastal waters of Newfoundland and Labrador, were provided by the Canadian Department of the Environment from December until June. Ships obtained ice information by contacting the Ice Operations Officer, Sydney, Nova Scotia via Sydney Marine Radio/VCO or Halifax Marine Radio/VCS.

Communications statistics for the period 1 September 1971 through 4 September 1972 are shown in TABLE 2.

TABLE 2.- COMMUNICATIONS STATISTICS

Number of ice reports received from ships	1151
Number of ships furnishing ice reports	402
Number of ice reports received from aircraft	30
Number of sea surface temperature reports	432
Number of ships furnishing sea surface temperature reports	99
Number of ships requesting special information	16
Number of NIK Ice Bulletins issued	378
Number of NIK FAX Broadcasts	188

Of all the ships furnishing Ice Patrol with special sea surface temperature observations there were ten outstanding contributers:

M/V Atlantic Span/SLPN
M/V Ampere/FNVL
USCGC Spencer/NRDS
M/V Banija/YTEK
M/V Francois/FNLH
R/V Chain
M/V Baltic Wasa/SMHR
M/V Commandant Bourdais/FBTF
M/V Atlanta/DIMR
M/V Michelangelo/ICVI

TABLE 3. - Estimated Number of Icebergs South of Latitude 48°N, Season of 1972

Season	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	(SEP*)	TOTAL
1972	0	0	0	0	0	40	185	501	559	225	48	26	(3)	1584 (1587)
Total 1946-1972	5	2	4	5	10	127	761	2351	2098	1293	294	38		6988
Average 1946-1972	0	0	0	0	0	5	28	87	78	48	11	1		259
Total 1900-1972	251	109	110	85	130	578	2863	7196	9181	4811	1490	427		27231
Average 1900-1972	3	1	2	1	2	8	39	99	126	66	20	6		373

* Season ended 04 September. These 3 bergs actually drifted south of 48°N during the 1972 Ice Season; however, to provide statistical continuity they are not included in either the 1946-1972 or 1900-1972 tabulations. They will be included in the September monthly tabulation for the 1973 Ice Season.

ICE CONDITIONS, 1972 SEASON

September - December

After the close of the 1971 Ice Patrol season, occasional icebergs continued to drift south along the Labrador coast. During September there was a report of an iceberg and growler in the eastern portion of the Strait of Belle Isle and another report of an iceberg and several growlers in its eastern approaches. On 2 October a large iceberg was reported in the middle of the Strait of Belle Isle. A total of seven iceberg reports plus several reports of growlers were received for the remainder of October, November and December, all north of the Strait of Belle Isle. In addition, one bergy bit was reported 160 miles east of Cape Bauld, Newfoundland on 3 November. By the end of December open pack ice extended down into the Strait of Belle, closing it to navigation.

January

There were no icebergs reported to the Ice Patrol office in January. During the period 10-14 January preseason flights were made along the Labrador and Baffin Island coasts as far north as Cape Dyer. The results of this flight are shown in figure 1. Iceberg counts in the area between Hudson Strait and Cumberland Sound were one-half the 1963-71 average of 293 icebergs. The counts south of Hudson Strait were two-thirds the 1963-71 average of 76. The latitudinal distribution is illustrated graphically in figure 2. The ice east of Newfoundland had undergone considerable disintegration as storms crossed the area in early January. By 20 January the southern ice edge was near 50-15N but the eastern edge was near 52W from 50-30N to 53N. The ice south of latitude 52-30N was mostly in the grey-white and grey stages and close pack except along the southern and eastern pack edges where new and grey ice predominated.

February

During the first half of February a group of twenty icebergs was reported by the USCGC DUANE enroute Ocean Station BRAVO. The southernmost of these was at 49-12N 48-34W on 8 February. Due to the presence of icebergs this far south, preseason iceberg reconnaissance flights were conducted 15-25 February, a week earlier than usual. Only four of the five scheduled tracks were flown due to mechanical difficulties on the aircraft. The results of this survey are shown in figure 3. Iceberg counts in the area between Hamilton Inlet and Hudson Strait were slightly more than half the 1963-71 average of 320 icebergs. The counts south of Hamilton Inlet were more than twice the 1963-71 average of 79. The latitudinal iceberg distribution is illustrated graphically in figure 4. The southernmost iceberg during the preseason flight was sighted on 17 February at 47-58N 47-17W. On the basis of the above, the Ice Reconnaissance Detachment was deployed to CFB Summerside, Prince Edward Island on 28 February and the 1972 Ice Season began officially on 29 February. It was estimated that a total of 40 icebergs drifted south of 48N during February as compared to 4 in a normal year. The southernmost berg in February reached a position of 44-52N 48-33W while the easternmost was at 46-43N 42-11W. Almost constant northwesterly winds and below normal temperatures combined with the Labrador current to cause a rapid southeastern spreading of the pack ice. The southernmost extension of sea ice varied between the latitude of Cape Race (46-40N) and 46N; the easternmost extension reached 46-20W. The outer 50 miles of pack ice and the area 20 to 50 miles off the coast of Newfoundland, south of Cape Freels consisted largely of close to open pack grey-white and grey ice with a few first year floes. North of 50-30N the pack consisted of mostly first year ice.

March

By early March, heavy sea ice extended well below Cape Race to near 46N and eastward in a east-northeast direction to about 200 to 250 miles offshore paralleling the Newfoundland coast northward, more than 100 miles beyond any known extreme. South of 48°N most of the ice was in the new and grey stages while farther north, grey-white and first year close to very close pack ice predominated. The sea ice was so heavy on the western coast of Newfoundland that 36 vessels were trapped in the vicinity of Cabot Strait during 3 to 6 March. There were no flights by the ice reconnaissance detachment during the first 9 days of March due to both poor weather and aircraft mechanical difficulties. During the next three days consecutive flights located a total of 72 icebergs, 13 growlers and 32 radar targets as shown in figure 5. The westerly winds during the previous two weeks and the heavy sea ice along the Newfoundland coast account for the grouping in the eastern portions of the search areas.

The ice edge remained below Cape Race at 46N and on 13 March reached its southernmost extension at 45-50N 53W. During the next week two more flights were attempted but very few icebergs were observed due to poor weather. On 20 March the pack ice east of Newfoundland lay several miles offshore from Notre Dame Bay eastward and southward to near 47-30N 52W then to 47N 48W, 51N 49W and northwestward. The central pack was very close first year ice as far south as 49N with lower concentrations of grey-white and grey ice along the edges. Then on 23 and 25 March 80 icebergs were located as shown in figure 6. Like earlier in the month, bergs were located in the eastern half of the search areas. Meanwhile the sea ice had extended itself to its easternmost limit at 45-50N 46W on 24 March. By the end of March the limits of all known ice had extended southward to 43-20N with 141 icebergs on plot as shown in figure 7. It is estimated that 185 bergs had drifted south of 48N in March 1972, the southernmost of which was at 43-21N and the easternmost at 45-49N 39-14W.

April

During the first week of April, 340 icebergs were located by the Ice Reconnaissance Detachment as shown in figure 8. It should be noted that an easterly wind component concentrated the distribution of bergs in the western half of the search areas. This tremendous gathering exceeded the normal for an entire season and was only an indication of things to come. The southernmost extension of sea ice was at 47N 48-50W at this time and consisted of open to close pack grey-white and white ice. The remainder was very close first year ice lying onshore from Cape Bonavista through Notre Dame Bay and northward along the coast. This began slowly receeding northward reaching 49-30N on 13 April. Then with a shift in wind the sea ice advanced southward again to 47-30N on 22 April. At the end of the month, the sea ice was concentrated just above 48N extending eastward 200 miles (to 49W). South of 49N and immediately inside the pack edge to 52N the ice concentration varied from open to very open pack. The remainder of the pack consisted of very close first year ice, much of it 2-4 feet thick. Another good series of flights was obtained by the Detachment during the week of 11 to 17 April locating 549 icebergs, 130 growlers and 37 radar targets as shown in figure 9. The bergs, as a result of being subjected to a norrthwesterly wind, were much more evenly distributed than as was previously shown. The icebergs continued their southeastward march reaching 40-40N 45-08W on 24 April. Then under the building influence of a southwesterly wind, the bergs drifted out of the Labrador Current and moved eastward and even east-northeastward for the remainder of the month. The easternmost berg was located on the last day of the month at 48-06N 41-27W. The iceberg limits at this time are shown in figure 10. It is estimated that 501 icebergs drifted across 48N as compared to 82 for the April normal.

May

The early May sea ice limits were stable with the eastern and southernmost limits at 48N 48W. A flight on 1 May over the western portion of the Grand Banks verified an earlier flight (over the middle and eastern parts) that all icebergs were indeed drifting eastward. Subsequent flights on 2 and 3 May located 550 icebergs poised as potential dangers to navigation for the remainder of the month as shown in figure 11. Some two weeks later, 267 of these bergs were relocated slightly south and east of the former locations. The sea ice, influenced by lower than normal temperatures and a southeastward wind induced drift, moved to an extreme of 46-40N 46-30W. The central pack moved northwestward starting at mid-month; however, a southeastward tongue was left behind extending to 46-10N 46-50W at the end of the month. At the latitude of Belle Isle the eastern edge was near 50W. This tongue consisted of open to very open pack ice. On 15 May, the easternmost iceberg of the 1972 Season was located at 47-02N 36-59W extending the limits of all known ice some 640 miles east of Newfoundland's Avalon Peninsula and encompassing some 175,825 square miles of area south of 48N as shown in figure 12. On 23 and 24 May two aircraft were assigned to the Ice Reconnaissance Detachment to take advantage of the short period of forecast good weather (the previous two weeks having been plagued with fog). They located a large concentration of bergs on the northeastern edge of the Grand Banks, scattered bergs on the eastern slope, and none at all on the Banks or south of it. The numbers and exact distribution are shown in figure 13. The southernmost icebergs of the season were computed to be in position 39-57N 45-06W on 23 May. The ice limits then encompassed 236,400 square miles, as shown in figure 14. On 27 May, 208 of the bergs sighted on 23 May were relocated and no further flights were made for the remainder of the month due to poor on scene weather. 559 icebergs drifted south of 48N as compared to a normal of 63.

June

On 3 June the main pack of sea ice was located above 50N with a narrow tongue extending almost 350 miles to the southeast as shown in figure 15. This tongue of very open pack ice receded until 10 June when its southernmost edge stabilized at 49N. With the Grand Banks completely fog-bound, the Ice Reconnaissance Detachment flew northward on 6 June to assess the iceberg potential for the remainder of the season. The flight located 1517 icebergs between 52N and 55N, from the coast to 49W. On 9 June the easternmost iceberg for the month had drifted to 47-07N 39-07W. On 13 June, with fog still persisting over the Grand Banks, a short flight between 49N and 50N from the coast to 49W located some 380 icebergs. A week later, on 20 June, a flight farther to the north between 50N and 52N from the coast to 47W revealed a record 3423 icebergs and growlers as a potential for the rest of the season.

The southernmost iceberg for the month drifted to 41-36N 48-46W on 22 June. By the end of the month the sea ice had gradually receded to 50N and consisted of open to close pack melting first year ice in the central pack and very open pack ice elsewhere. The limits of all known ice were then as shown in figure 16 with 133 icebergs on plot south of 48N. The southernmost 23 bergs had been located by a flight on 28 June. During June it is estimated that 225 icebergs drifted south of 48N as compared to 40 in a normal year.

July

In early July the sea ice consisted of rapidly disintegrating open to very open pack ice north of 50N. By 9 July the Strait of Belle Isle was open to maritime traffic and the ice pack had receded to 54N on 11 July. With a dominant wind from the southwest, the large concentration of icebergs located in June between 50N and 52N never drifted south of 49N. This wind also continued to generate a constant fog over the Grand Banks making reconnaissance flights next to impossible. Throughout the month, weekly flights were conducted south of the Tail of the Banks to update the southernmost iceberg positions. On 17 July another flight between 50N and 52N showed 1476 bergs distributed between the coast and 48W. Fog persisted for almost the entire month between 43N and 50N, but partially abated during the last week so that a series of flights could be flown in this area. The tracks covered on 26, 27 and 29 July are shown in figure 17. By the end of July, an estimated 48 icebergs had drifted south of 48N. The limits of all known ice are shown in figure 18.

August

Flight operations on 1, 2 and 4 August showed only two icebergs south of 45-30N as shown in figure 19. Two additional flights on 10 and 12 August located 73 bergs posing a significant threat to shipping. (See figure 20). The eastward wind-induced drift moved them into warmer waters and most melted within a few days. On 18 August a flight covering the eastern slope of the Grand Banks revealed only three surviving icebergs. No further flights were possible for the remainder of August due to the poor weather on scene. Many icebergs were continuously being reported in the Strait of Belle Isle and its eastern approaches by passing ships. The iceberg limits at the end of August are shown in figure 21. It is estimated that a total of 26 icebergs drifted south of 48N.

September

On 1 September the final flight of the season located 3 icebergs as shown in figure 22. Two bergs were also reported by ships on the same day. On 4 September, the 1972 Ice Season officially ended with three additional bergs drifting south of 48N during these four days. The final iceberg limits are shown in figure 23. Thus ended the longest and heaviest iceberg season on record.

OCEANOGRAPHIC CONDITIONS, 1972

A. D. ROSEBROOK

(U.S. Coast Guard Oceanographic Unit)

Three oceanographic cruises during the period 3-23 April, 5-22 May, and 3-22 June 1972 were conducted in support of the International Ice Patrol aboard USCGC EVERGREEN (WAGO-295). Salinity and temperature data were collected to a depth of at least 1000 meters using a Salinity-Temperature-Depth (STD) Sensor System. Data were recorded on magnetic tape using a digital data logger further processing upon return to the C.G. Oceanographic Unit. From these processed data, charts of dynamic topography of the sea surface relative to the 1000 decibar level of no assumed motion were constructed (figures 24-26). The dynamic topography charts show several prominent features of the general circulation pattern on the Grand Banks. The Labrador Current can be seen flowing southward along the eastern slope of the Grand Banks near the 1000 meter depth contour. Located to the east is a dynamic trough separating the colder Labrador Current waters from the northward flowing North Atlantic Current water. Water from the dynamic trough is characterized by its low specific volume resulting from mixing between the two currents

The dynamic topography charts of the Grand Banks region from the three surveys agreed well with the normal or average dynamic topography for the months of April, May, and June. There was evidence of an additional dynamic low in the vicinity of 44°N, 47°W during the April survey (figure 24). During the May survey, a poorly defined dynamic low was observed farther to the east near 44°N, 46°W (figure 25). The modified survey taken during June did not extend far enough to the east to determine if a dynamic low was still present during this period. During the period 7-15 June, EVERGREEN was assigned as Surface Patrol Vessel and stood by a large tabular iceberg (mass approximately 3 x 10^9 kgs.) located near 42.5°N, 49.5°W. While standing by the iceberg, EVERGREEN occupied a series of 12 oceanographic stations around the berg. As a result, a total of 28 stations was taken in a rather small area during the survey. The resulting dynamic topography of this region is much more complex than that found in the remainder of the survey area (figure 26).

Preliminary analysis of the data collected during the surveys indicated that the water temperatures of the Labrador Current and on the Grand Banks were generally colder than normally encountered. Except for an unusually strong geostrophic current of 2.3 knots observed near 44°37'N, 49°02'W on 14 May, the maximum value of the Labrador Current seldom exceeded 1 knot. The colder water temperatures and almost constant current velocities were two of the factors contributing to the record number of icebergs (1587) encountered south of 48°N during the 1972 season.

A more detailed analysis of the oceanographic of the Grand Banks in 1972 will be published in the U.S. Coast Guard Oceanographic Report Series (CG-373).

DISCUSSION OF ICEBERG AND ENVIRONMENTAL CONDITIONS

1972 ICE SEASON

In attempting to explain the environmental factors producing a record season, both in longevity and number of icebergs, four major conditions must be considered. First is the number of icebergs available to drift south of 48°N latitude, second is the strength and duration of the northwesterly wind component producing a drift which transports the icebergs south, thirdly, the development of the features of the Labrador Current, and finally, the reduced rate of deterioration of the icebergs due to colder air and sea temperatures and wave action inhibited by sea ice.

The total number of icebergs counted during the pre-season flights (194 in January, 360 in February) makes up but a small part of those icebergs which drifted south of 48°N latitude. The January survey went only as far north as Cape Dyer and the February flight extended to Cape Chidley. Normally this is all that is necessary as the icebergs north of Davis Strait rarely survive the 1000-mile drift without melting. This ice season, as will next be discussed, was by no means normal.

Figures 27a through 27e show the normal and the 1971/1972 surface pressure patterns for November through August. During December a strong low pressure system centered near the southeastern tip of Greenland became clearly defined. Then for the next six consecutive months a strong northwesterly wind anomaly persisted. These extreme, excessive conditions caused thousands of icebergs to drift out of Baffin Bay, through Davis Strait and into the Labrador Current. This same intensification created a mean southwesterly wind over the Grand Banks by late February which remained until early July. Thus the majority of icebergs were forced out of the influence of the Labrador Current and drifted eastward into the somewhat warmer waters of the North Atlantic Current.

Examining each of figures 27a through 27e more closely, the November Greenland High and a 4-mb positive anomaly lay over the northern half of Greenland with the mean pressures from Labrador westward as much as 5 mb above normal. The Icelandic low was way out of position over the Barents Sea (normally south of Denmark Strait) and 8 mb below normal. A trough of low pressure extended southward from Baffin Bay through the Labrador Sea into the waters well south of Newfoundland. Pressures inside the trough ranged from 4 mb below normal near 40°N 55°W to 7 mb above normal near the low pressure system west of Kap Farvel.

During December the Icelandic Low near 61°N, 34°W was 4 mb below normal and about 125 miles offits mean monthly location. The 1014-mb Greenland High was 2 mb weaker than normal. A negative 5-mb anomaly was located about 500 miles east of Cape Race near 48°N, 40°W. A positive 6-mb anomaly over eastern Quebec brought pressure departures of more than 4 mb to the western Labrador Sea.

January found the Icelandic Low near 61°N, 40°W and 16 mb below normal. It was only about 100 miles west of its average monthly location. In February the 994-mb Icelandic Low near 59°N, 30°W was 8 mb below normal and 300 miles east of its mean position. This large negative anomaly was the only significant low over the North Atlantic. A slightly stronger than normal Greenland High resulted in positive 5-mb anomalies south of 75°N, 33°W.

During March the 998-mb Icelandic Low near 63°N, 35°W was 6 mb below normal and about 350 miles northeast of its mean location. A weak 1014-mb low was near Cape Sable, Nova Scotia. Two 8-mb positive anomalies lay east of Newfoundland centered near 49°N, 44°W and 46°N, 30°W. The 1016-mb Greenland High was 4 mb below normal.

April shows the Icelandic Low (1005 mb) as a trough extending from the Labrador to the Norwegian Seas. The Greenland High (1026 mb) near 76°N, 38°W was 4 mb above normal. In May the Icelandic Low near 60°N, 26°W further intensified to 5 mb below normal and was located about 300 miles northeast of its average position. West of the Icelandic Low, pressures near Kap Farvel were 7 mb below normal.

During June a positive 8-mb anomaly lay over the central North Atlantic near 45°N, 37°W and a negative 10-mb anomaly was south of Iceland near 62°N, 18°W. The Icelandic Low itself (1002 mb) was more than 8 mb below normal. The 1015 mb Greenland High near 76°N, 38°W was close to normal. July found the Greenland High (1014 mb) near normal in central pressure but 400 miles northwest of its average position for the month at 77°N, 44°W. The Icelandic Low split into two parts, the stronger (1008 mb) off the west coast of Iceland, the weaker (1010 mb) near Cape Smith (Hudson Bay). During August, average pressures were from 1 to 3 mb above normal over almost the entire North Atlantic.

To determine and assign numerical values to the existing wind conditions, surface pressure gradients (differences in atmospheric pressure along a geographically orientated line) may be used. Four such gradients are labeled in figure 28. Gradients 1 and 2 measure the winds which are important in setting up the drift for transporting icebergs to the general area of the waters off northeast Newfoundland. Gradient 3 measures the component which assists or impedes icebergs as they drift along the eastern slope of the Grand Banks. Gradient 4 is a measure of the influence of the generally westerly winds along the northern slopes of the Grand Banks. This is important in drifting the icebergs away from the northeast Newfoundland coast and into the Labrador Current. If, however, they are too strong (or persistent) when the icebergs reach the northeast corner of the Grand Banks they may be carried eastward out of the Labrador Current and into warmer waters which drift generally northeastward (as happened this year).

Referring now to the graphical representations of figure 29, Gradient 2 is significantly above normal while gradient 1 averaged more than twice the normal magnitude of favorable southward-induced iceberg drift. These persistent winds provided a constant iceberg supply to the waters off northeast Newfoundland. Gradient 3 shows an unfavorable drift along the eastern slopes of the Grand Banks while Gradient 4 shows a tendency for iceberg drift eastward out of the Labrador Current, especially during the months of April, May and June. Had either or both pressure Gradients 3 and 4 been closer to normal, hundreds (perhaps even thousands) more icebergs could have drifted south of 48°N.

December air temperatures along the Baffin Island, Labrador and Newfoundland coasts set a record low. Temperatures continued much colder than normal during the remaining winter and all the spring months as shown in figure 30. Temperatures averaged in excess of 7°F below normal. The locations of the stations are shown in figure 28. A frost degree day, as used in figure 30, is defined as one day at a temperature of one Fahrenheit degree below 32° (e.g., one day at 20°F would be 12 frost degree days). Similarly a melting degree day is one day at a temperature of one Fahrenheit degree above 32°. All the stations had a much greater than normal frost degree day accumulation and all but St. John's, Newfoundland had a smaller than normal melting degree day accumulation. Adding these influences together, iceberg deteioration due to both wave action (inhibited due to the large extent of sea ice already discussed in a prior section) and melting was greatly retarded thus extending the Ice Season approximately two months longer than normal.

ICE AND SEA SURFACE TEMPERATURE REPORTS
RECEIVED FROM SHIPS OF PARTICIPATING NATIONS
DURING 1972

BELGIUM	ICE	SST
BELVAL	1	
DART EUROPE	2	
FEDERAL SCHELDE	1	
MINERAL SERAING	2	

CANADA	ICE	SST
ALERT	3	3
AMOCO CANADA SUPPLY VESSELS	2	
HMCS ANNAPOLIS	3	
CCGS BAFFIN	6	
CAPE FREELS	1	
CCGS HUDSON	1	
J.E. JONSSON	4	
LOUIS ST. LAURENT	2	
MARY B VI	1	
NARWHAL	7	
CS NORTHERN	1	
PROTECTEUR	36	1
QUEBEC	1	
QUEST	1	
SACKVILLE	1	
HMCS SKEENA	7	

DENMARK	ICE	SST
BYMOS	1	
ESKIMO	1	
FREEZER SCAN	1	
GRETE SKOU	2	
HEERING ELSIE	3	
HELGA DAN	3	5
LEISE MAERSK	2	
RITVA DAN	2	
SLESVIG	3	2

FINLAND	ICE	SST
ATLAS	1	
FINN AMERICAN	1	
GERMUNDO	4	7
HANSA	3	
SOLANO	1	1
UNARI	3	

FRANCE	ICE	SST
ALEX PLEVEN	1	
AMPERE	30	25
ANDROMEDE	19	2
ATLANTIC CHAMPAGNE	2	
CATHERINE	1	
CHRISTINE	5	7
COMMANDANT BOURDAIS	7	13
FRANCE	5	
FRANCOIS L.D.	6	19
JEAN SCHNEIDER		4
PENGALL	2	
PENRUZ	2	
MICHIGAN	1	
MONT LAURIER	2	1
ONDINE	1	
PENERF	2	
VILLE DE MEXICO	1	
ROBERT L.D.	1	

FEDERAL REPUBLIC OF GERMANY	ICE	SST
ALSTER EXPRESS	2	
ANNA KATRIN FRITZEN	1	
ANNA REHDER	3	3
ANNA WESCH	3	
AROSIA	2	
ATHENE	2	
ATLANTA		11
ATLANTIC CINDERELLA	3	1
ATLANTICA LIVORNO	2	2
ATLANTICA NEW YORK	1	
AUGUSTE SCHULTE	1	
BARI	5	
BOCKENHEIM	7	
BORNHEIM	1	
BOSTON SAND	1	
BRAGE		3
BUCHENSTEIN	1	
CARSTEN RUSS	3	
DORTHEA BOLTEN	1	
ECKERT OLDENDORF	1	
ELBE EXPRESS	4	
ELIZABETH OLDENDORF	1	1
ELSFLETH	3	
EUROPA	1	
HAMBURG	1	
HANS BORNHOFEN	1	
HARTFORD EXPRESS	1	
HAVELLAND	1	1
HERMANN SCHULTE	4	
IDA BLUMENTHAL	1	

	ICE	SST
ISABELLA	1	
JENNES	1	
JOHANNES RUSS	1	
JORG KRUGER		8
JOSEF STEWING	1	
JOULLA	2	
JUDITH SCHULTE	2	
LUISE BORNHOFEN	1	
MAIN EXPRESS	3	
MARITA LEONHARDT	1	
MAX BORNHOFEN	1	
MAYSTIGHOLD	1	
MONIQUE SCHROEDER	5	
MOSEL EXPRESS	2	
PASSAT	2	
PAUL LORENZ RUSS	1	
PETER WESCH	1	
POLAR PARAGUAY		3
RANDO	1	
RENDSBURG	1	
SAARLAND	1	
SLOMAN SENIOR	2	
SUSANNE FRITZEN	3	2
TAEPING	2	1
TRANSAMERICA	3	
TRANSATLANTIC	3	
TRANSCANADA	2	
TRANSONTARIO	2	
WESER	2	3
WIEN		1
<u>GREAT BRITAIN</u>		
AFGHANISTAN	11	6
ALBRIGHT EXPLORER	2	
ALBRIGHT PIONEER	5	
ARCTIC SHORE	1	
ARCTIC TROLL	5	3
ASIA LINER	1	
ATLANTIC CAUSEWAY	2	1
ATLANTIC CONVEYOR	3	1
AVONFIELD	3	3
BEAVER PINE	1	
BELLNES	1	
BRIMMES	1	
BRITISH HERO		
BRITISH OFFICER	1	
BRITISH SWIFT	1	
BRITISH VISION	1	

	ICE	SST
C.P. AMBASSADOR	26	
C.P. DISCOVERER	6	1
CP EXPLORER	6	1
C.P. TRADER	8	
CP VOYAGEUR	9	2
CAPE HOWE	3	
CITY OF CANBERRA		6
CHERRYWOOD	1	
CHEVOIT	1	
DART AMERICA	3	
DART ATLANTIC	2	
DUKESGARTH	1	
DUNGRAIG	8	2
DUNKYLE	1	
EDENMORE	1	
FARSISTAN	1	
GLOXINIA	1	
GOTHLAND	2	
INISHOWEN HEAD	8	2
INVERALMOND	1	
KING ALFRED	2	2
KING JAMES		4
KNIGHTSGARTH		1
LA SIERRA	2	
LECTWORTH	1	
LONGSTONE	3	
LOTTINGE	2	
LYMINGE	1	
MANCHESTER CHALLENGE	1	
MANCHESTER CONCEPT	11	
MANCHESTER CONCORDE	10	
MANCHESTER COURAGE	6	
MANCHESTER CRUSADE	3	
MANCHESTER QUEST	6	
MATINA	1	
MONKSGARTH	3	1
NEWFOUNDLAND	3	1
NICOLAS BOWATER	3	
NIGARISTAN	2	
NOVA SCOTIA	1	1
ORESSA	2	
OTHELLO	3	
OVERSEAS ADVENTURE	1	
OXFORDSHIRE	1	
PHOTINIA	1	
QUEEN ELIZABETH II	7	
QUEENSGARTH	2	
RATTREY HEAD	1	

	ICE	SST
ROSEWOOD	2	
SILVER SHORE	1	
SCOTTISH WASA	2	
TEKOA	1	
TORONTO CITY	2	3
TORR HEAD	3	
VANCOUVER ISLAND	1	
WELSH HERALD	4	
WILKAWA	1	
ZINNIA	3	
GREECE		
ARIEL	1	
ARIES		1
ATHLON	2	
CALLIROY	2	
CALYPSO	1	
COSTAS FRANGOS	1	
FEDERAL SEAWAY	8	8
GRECIAN VALOUR	1	
KHIAN WAVE	1	
KING LEONIDAS	1	
KING NESTOR	2	
LILYM	1	
PROSO	1	1
QUEEN ANNA MARIA	4	5
RUDOLF LEONHARD	1	
SCAPLAKE	1	
SOPHIA COLOCOTRON	1	1
STEELY CARRIER	1	
TARPON SANDS	1	
TITIKA HALCOUSSI	1	
CALL SIGN - SYHF	1	
ISRAEL		
ARAD	1	
MEZADA	7	
TIMNA	1	
ITALY		
CRISTOFORO COLOMBO		1
GIOVANNI AGNELLI	2	
INTEGRITAS	1	
LEONARDO DA VINCI		3
MICHELANGELO	2	10

JAPAN	ICE	SST
ASAMA MARU		1
KANAGAWA MARU	3	
MIKUNISAN MARU	2	
TSURUGA MARU	4	
LIBERIA		
AEGEAN SKY	1	
ALKOR	1	4
ASTERI	2	
BELLE MICHAELS		2
CAPE PALMAS	1	
CORONADO	2	
CORTEREAL	1	
CYNTHIA		3
DORADO	3	
GRECIAN ISLES	1	
HEGOLAND	2	
HELENE	1	
ILKON NIKI	1	
KONKAR PIONEER	1	
LAMDA	1	
LIBERTY BELL		1
MAIN ORE	1	2
MELTEMI	1	
MOZART	1	
NAESS SPIRIT	1	
NEW HAVEN	9	
NEW HORIZON	2	
OLYMPIC PALM	1	
ORIENTAL CLIPPER	2	1
OSWEGO VENTURE	2	
PATIGNIES	1	
PHOSPHOROUS CONVEYOR	1	
RIO MACAREO	1	
STOLT ATLANTIC	1	
VOLTA VIGILANCE	2	
WHITE RIVER	1	
NETHERLANDS		
ABIDA	2	
ACILA		1
ASMIDISK		2
ATLANTIC CROWN	1	
ATLANTIC STAR	3	
CLYDE	1	

	ICE	SST
GREBBEDYK	1	
LEO POLARIS	1	
RIJN	1	
STELLA NOVA	2	
STOLT MUNTTOREN	2	

NORWAY

	ICE	SST
ANETTE	3	2
ANGELITA	1	
ANITA	1	2
ARAPRIDE	1	
BANAK	1	
BARDU	1	
BELBLUE	2	1
BELCARGO		3
BETH	2	
BOW CEDAR	1	
BRUNITA	1	
CONDO	1	
EVITA	1	
FERNLEAF	3	1
FERNSIDE	2	
FINSHIP	1	
FOSSUM	1	
GRONG	1	1
HARDANGER	1	
HAVIS	1	
HAVMANN		2
HELENE PRESTHUS	3	
HERULV	1	
HOEGH MERCHANT	3	
HOEGH MERIT	3	
IDEFJORD	3	
JANOVA	2	
JAROSA		2
LIANA	2	
LIVANITA	5	
MARDINA COOLER	3	
MARGARITA	1	
MUNDOGAS BERMUDA	1	
NAESSCOMET	1	
NANFRI	1	1
NOPAL REX	1	
NORSE CARRIER	1	6
NORSE RIVER	4	
NORSE TRANSPORTER	1	7
NORSE VARIANT	1	
ROBERT STOVE	1	
ROSS SEA	1	
SAGAFJORD	5	
SANDVIKEN	1	
SKIENSFJORD	3	
SNELAND	2	
STOVE SCOTIA	1	
TOPDALSFJORD	3	
TRESFONN	1	
VIGAN	1	
VIKFROST	1	
WILFRED	2	2

PANAMA

	ICE	SST
ASIA FIDELITY		2
ESSO SANTOS	1	
FEDERAL SALSO	1	
HAMBURGER MICHEL	1	
LOCARNO	1	

SPAIN

	ICE	SST
AIBOA	2	
LLARANES	5	
MANCHESTER RAPIDO	1	
MARECOSA	2	
PLAYA DE LAS NIEVES	1	
SIERRA JARA	1	
TRASONA	2	
CALL SIGN - EGAQ	1	

SWEDEN

	ICE	SST
ADAK	2	
ATLANTIC SPAN	2	58
AVAFORS	5	
AVENIR	2	
BALTIC WASA	3	13
EXPECTATION	1	
FALSTER	1	
FINLAND	1	
GRIPSHOLM	1	
LAPONIA	4	
OKANAGAN VALLEY		1
SEGERO	2	4
TAVASTLAND	1	1

UNITED STATES OF AMERICA

	ICE	SST
AMERICAN ARGOSY	2	2
AMERICAN DELTA II	1	
BOSTON	1	
CV LIGHTNING	3	
C.V. SEA WITCH	1	

	ICE	SST
CHAIN	6	18
COMMANDER	1	
GENTOL		1
KNORR		7
LASH TURKIYE	1	
NIOBE	6	
STAGHOUND	4	
TRIDENT	1	7
YOUNG AMERICA	1	
U.S. COAST GUARD CUTTERS	253	52
U.S. NAVY SHIPS	5	0
<u>YUGOSLAVIA</u>		
BANIJA	6	16
BIOKOVO	1	
BOSANKA		2
LJUBIJA	1	

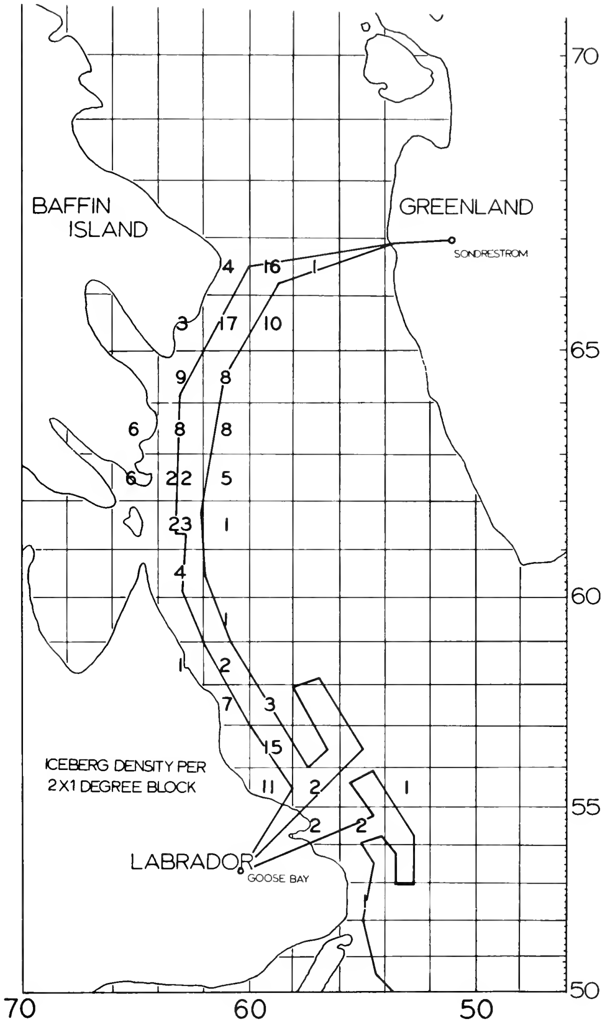

FIGURE 1.—Pre-season Iceberg Survey, 10–14 January 1972.

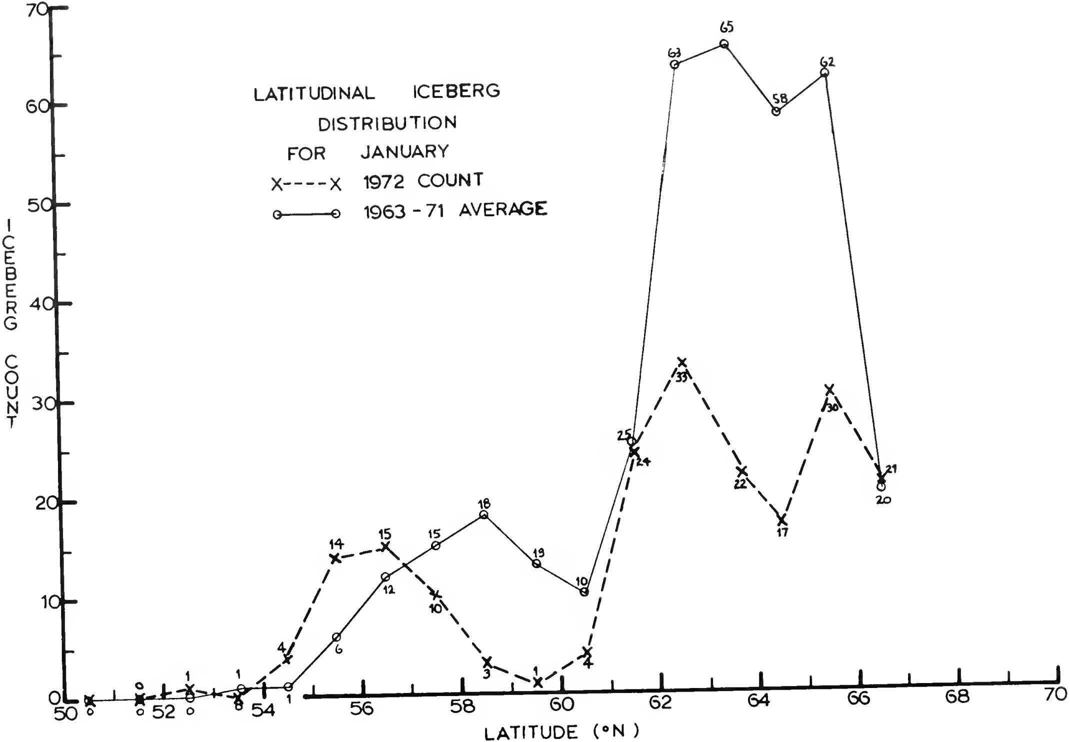

Figure 2.—Latitudinal Iceberg Distribution, January Pre-Season Flight.

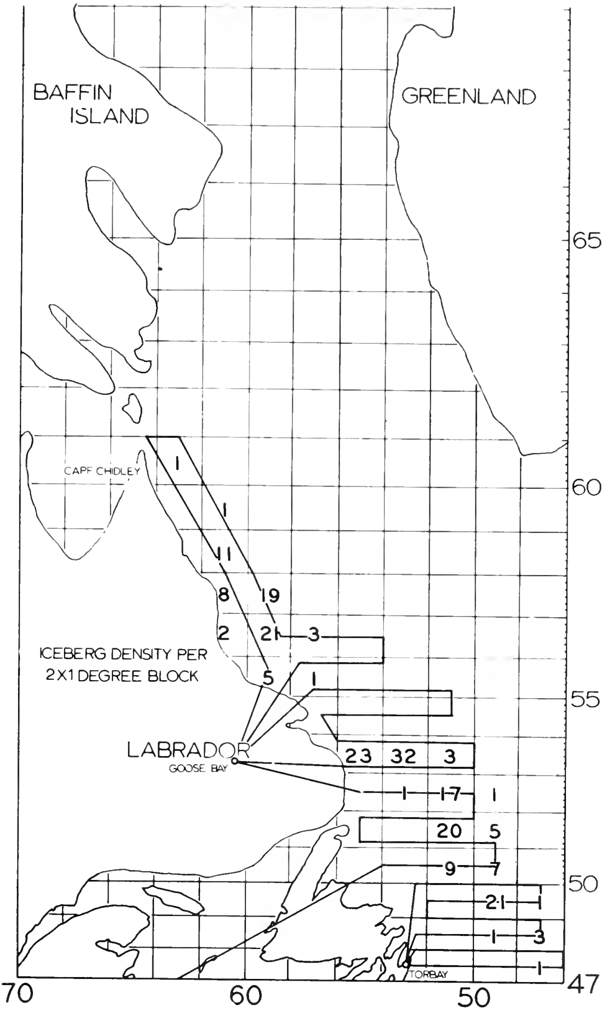

FIGURE 3.—Pre-Season Iceberg Survey, 16–26 February 1972.

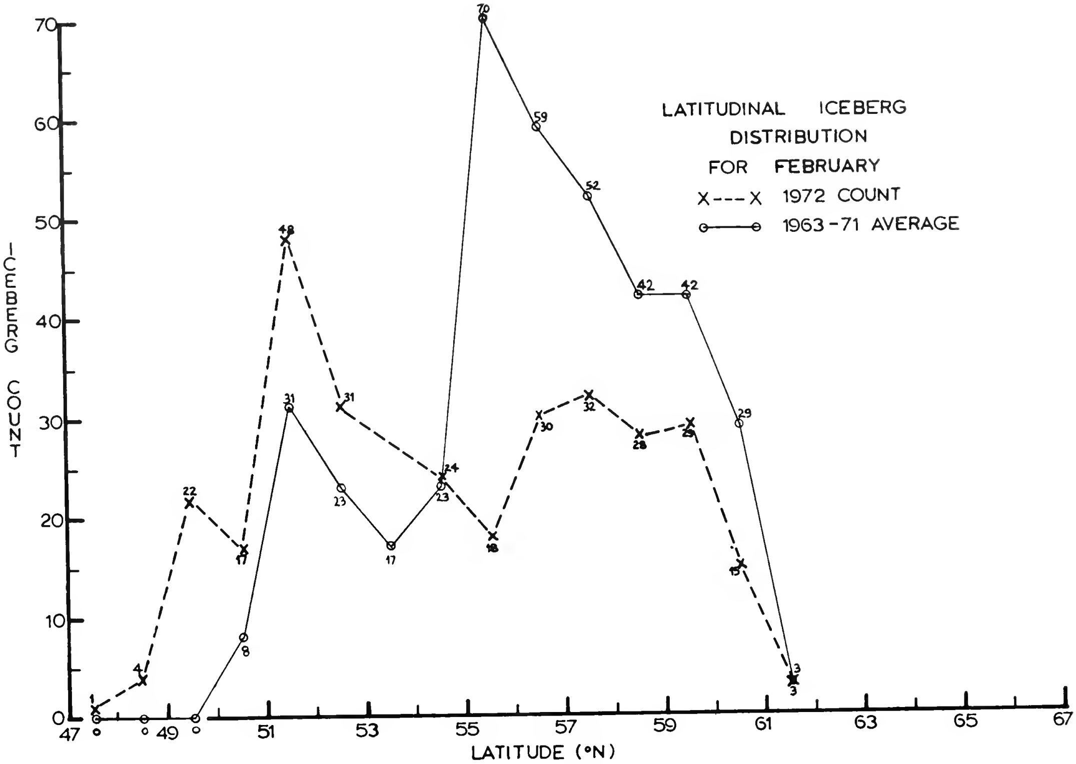

FIGURE 4.—Latitudinal Iceberg Distribution, February Pre-Season Flight.

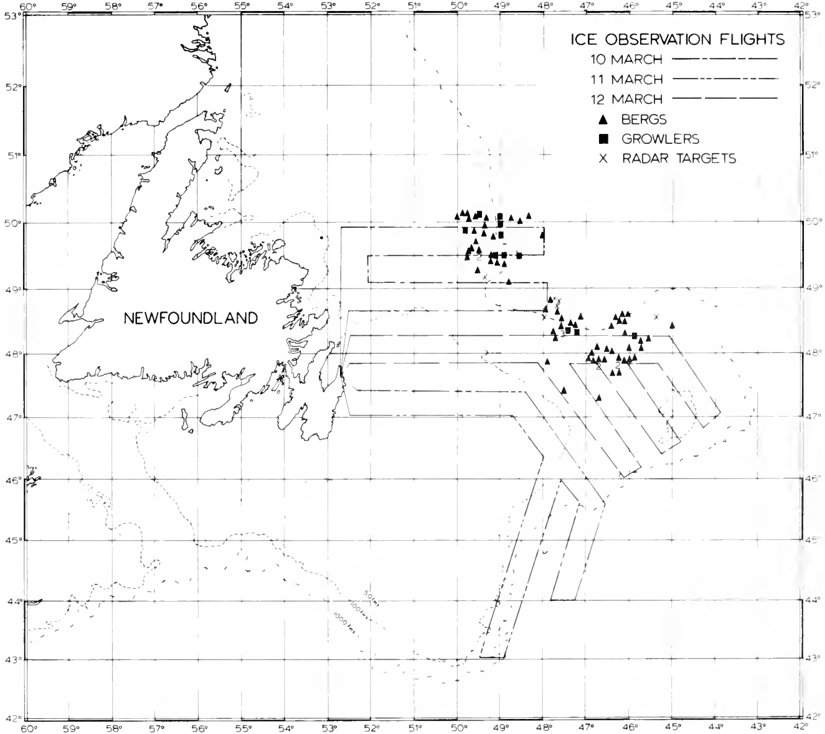

Figure 5.—Ice Observation Flights 10–12 March 1972.

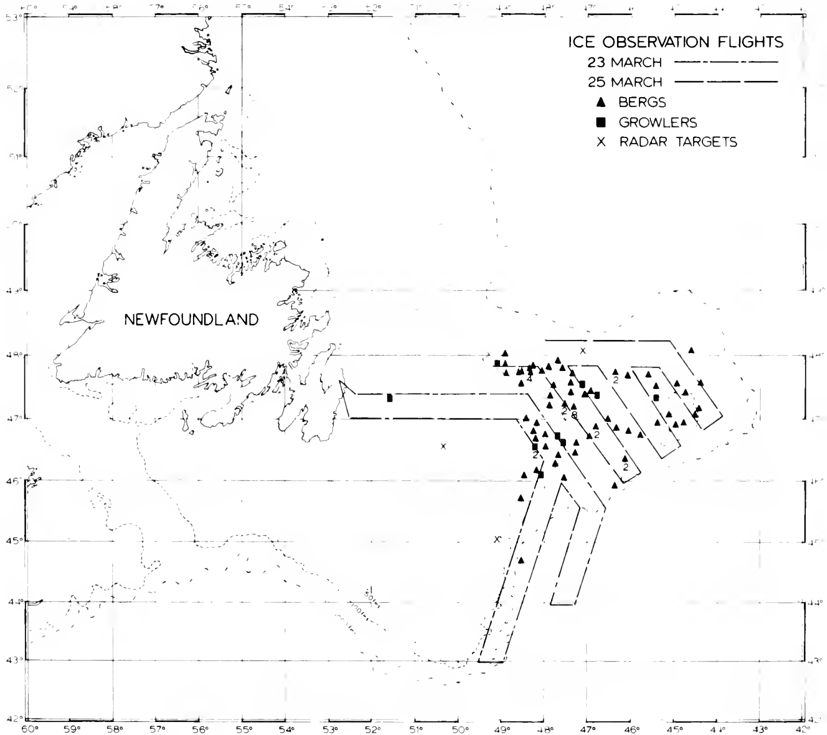

Figure 6.—Ice Observation Flights 23 and 25 March 1972.

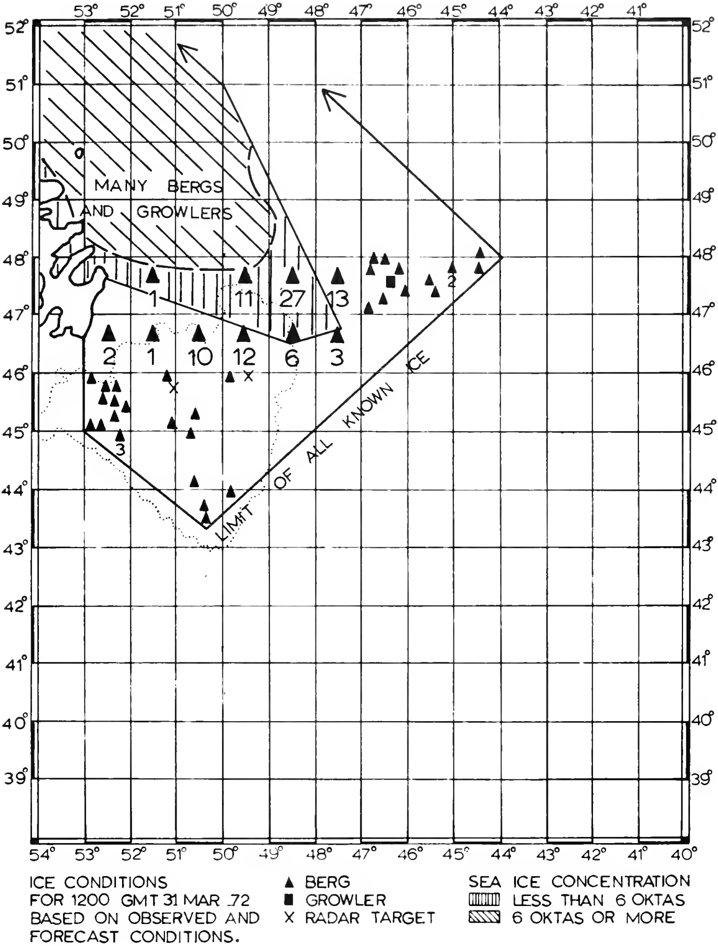

FIGURE 7.—Ice Conditions, 1200 GMT 31 March 1972.

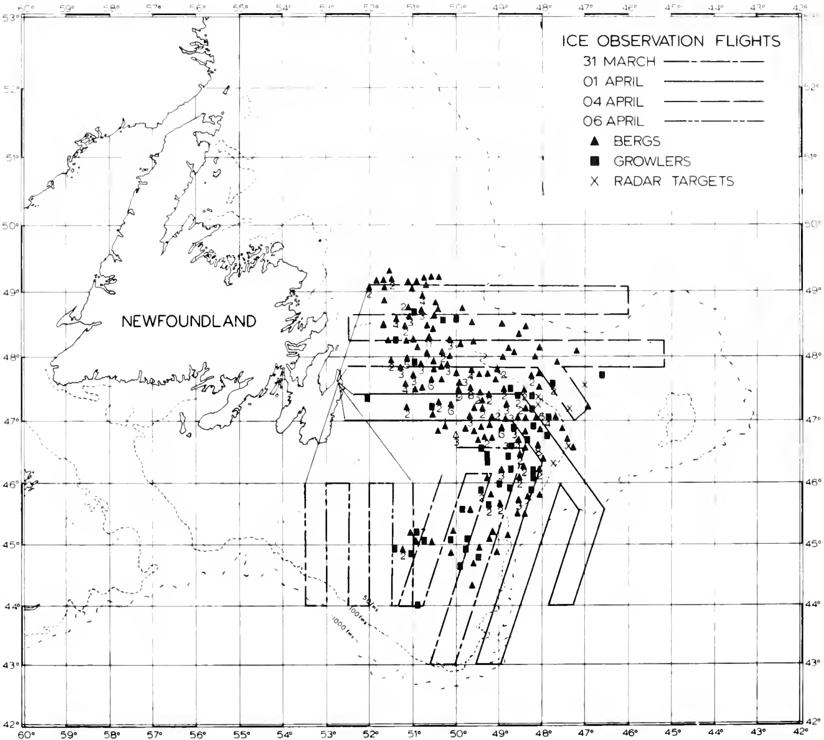

FIGURE 8.—Ice Observation Flights 31 March–6 April 1972.

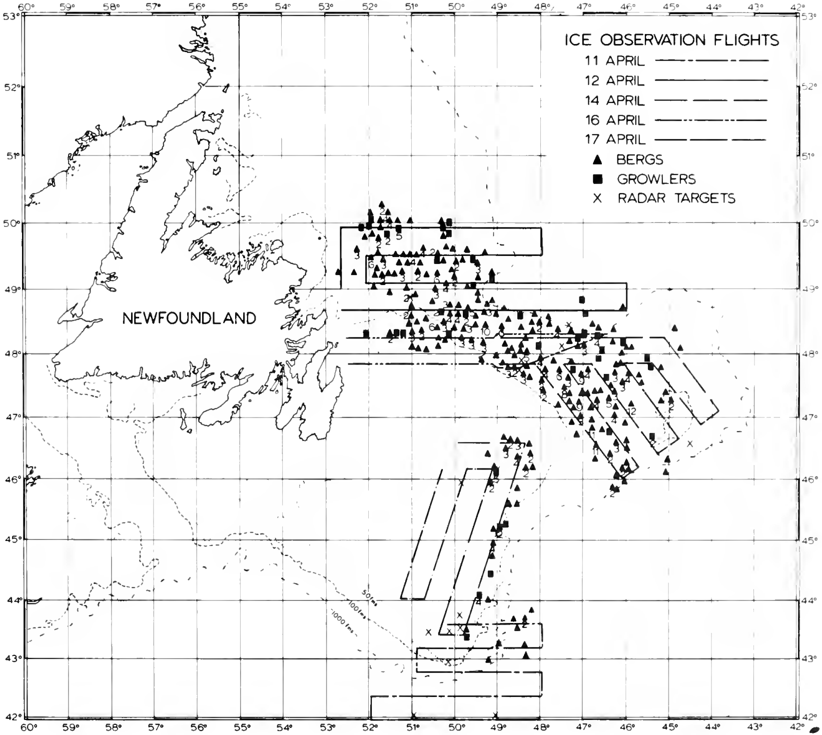

FIGURE 9.—Ice Observation Flights 11–17 April 1972.

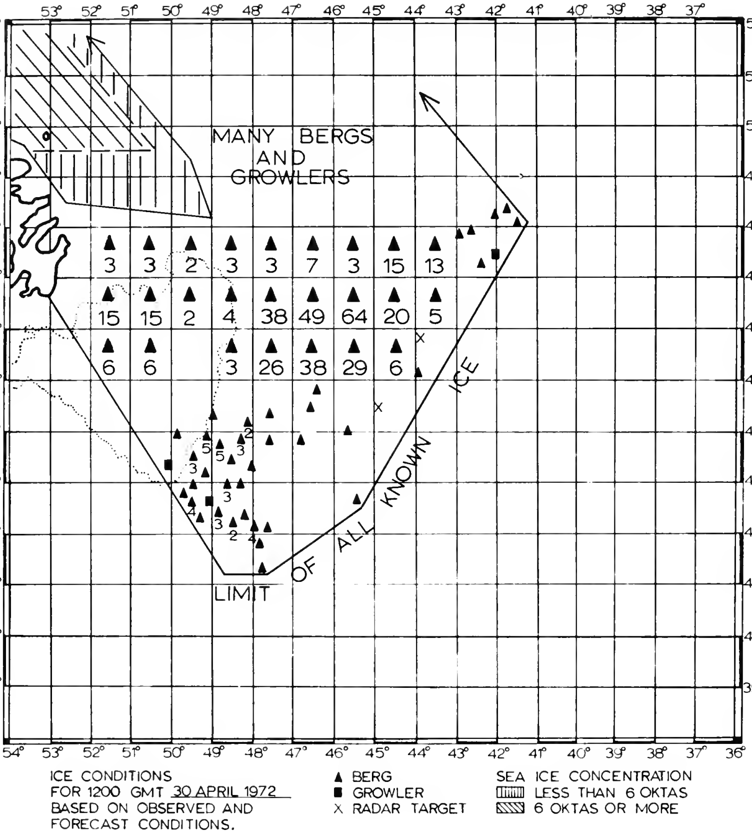

FIGURE 10.—Ice Conditions, 1200 GMT 30 April 1972.

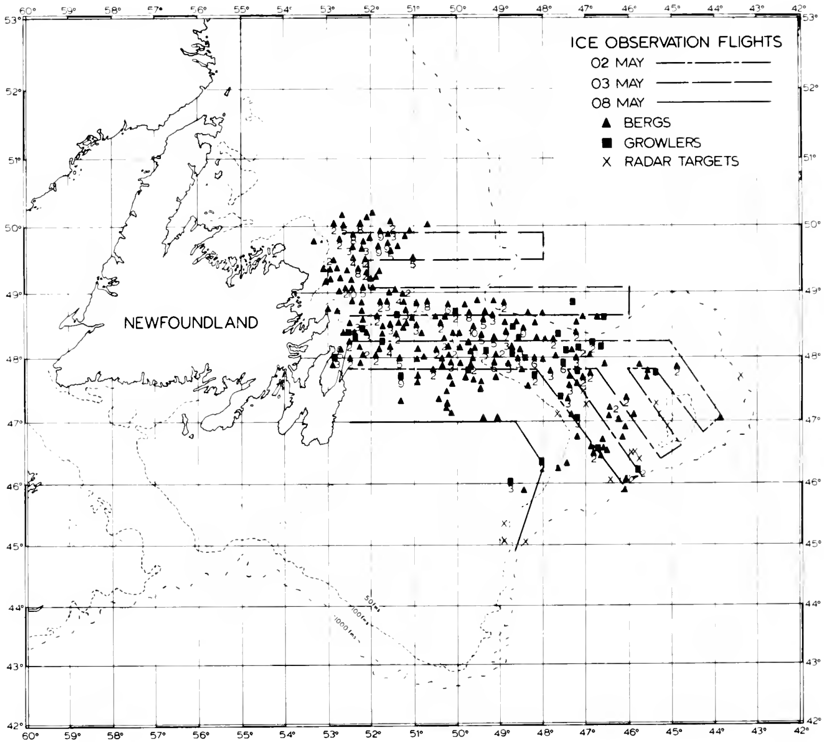

FIGURE 11.—Ice Observation Flights 2–8 May 1972.

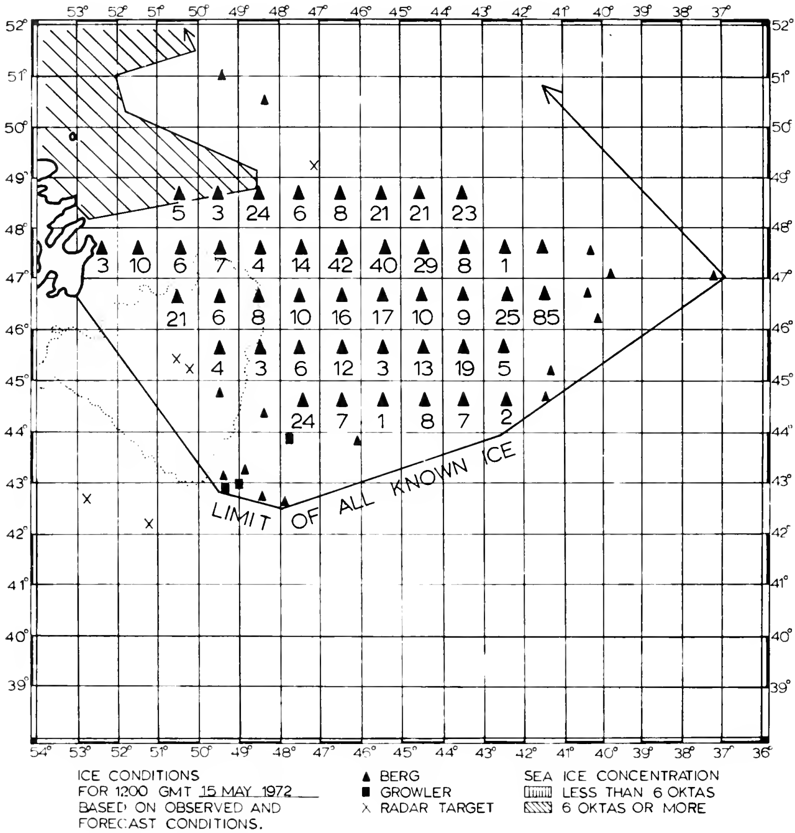

FIGURE 12.—Ice Conditions, 1200 GMT 15 May 1972.

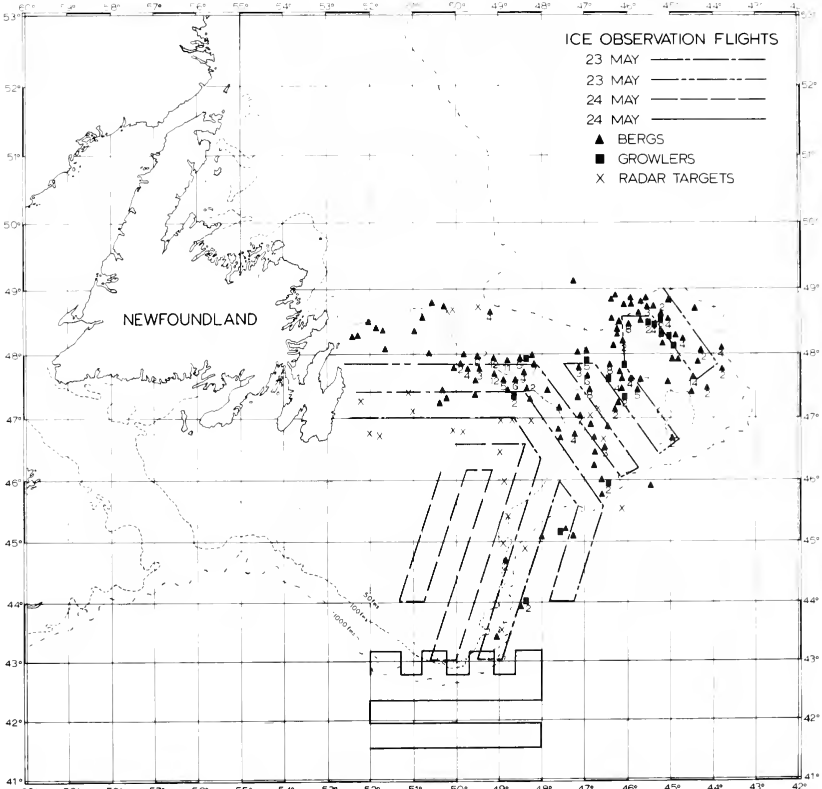

Figure 13.—Ice Observation Flights 23 and 24 May 1972.

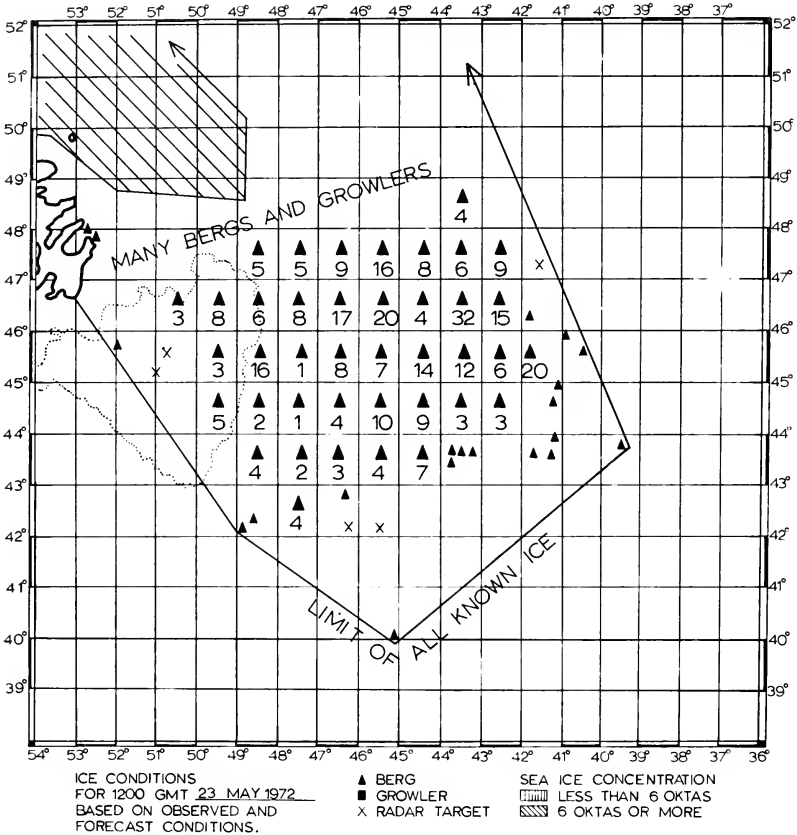

Figure 14.—Ice Conditions, 1200 GMT 23 May 1972.

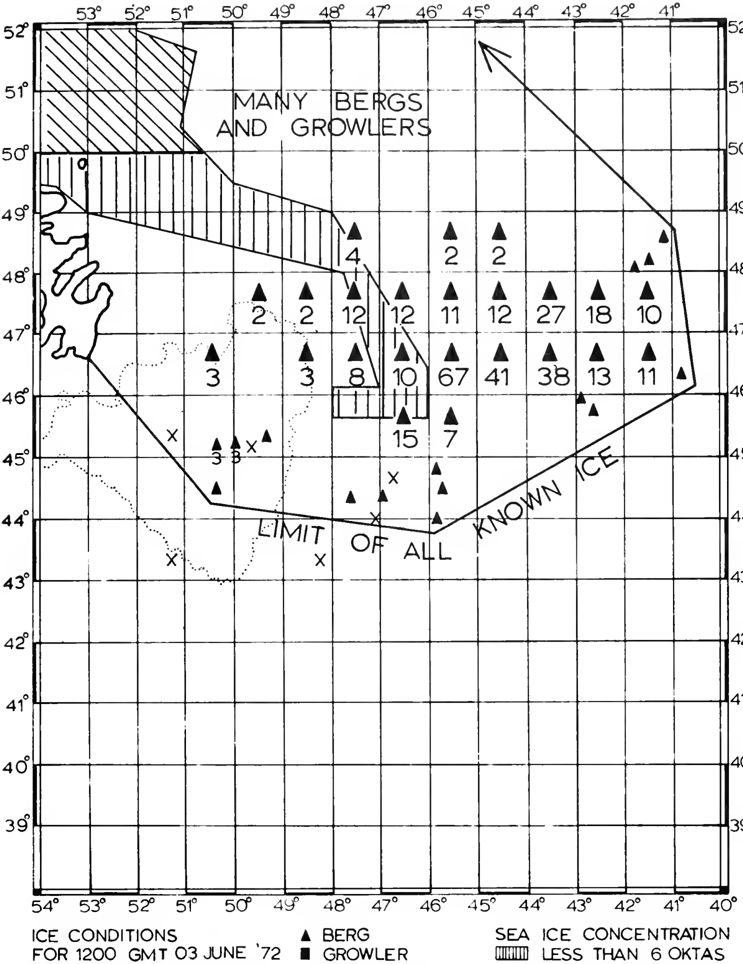

FIGURE 15.—Ice Conditions, 1200 GMT 3 June 1972.

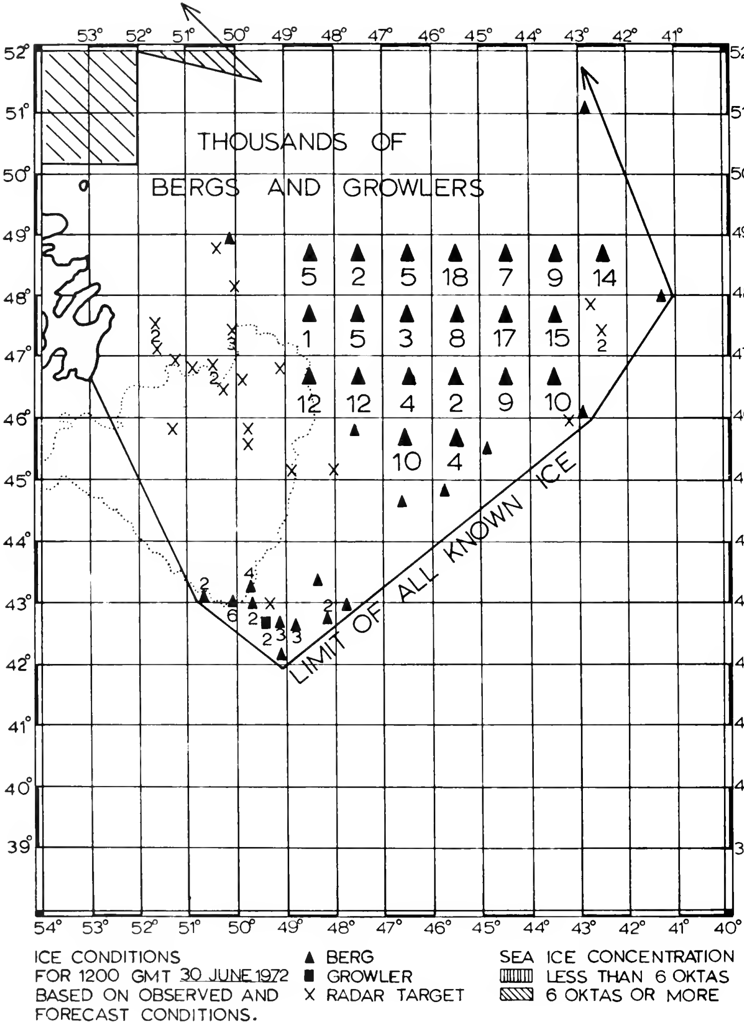

FIGURE 16.—Ice Conditions, 1200 GMT 30 June 1972.

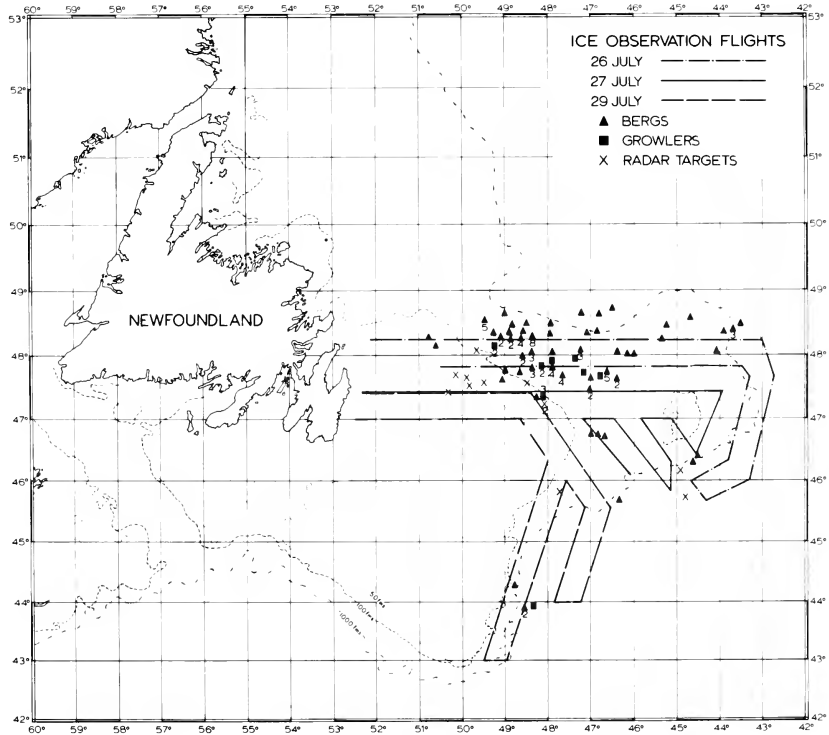

FIGURE 17.—Ice Observation Flights 26–29 July 1972.

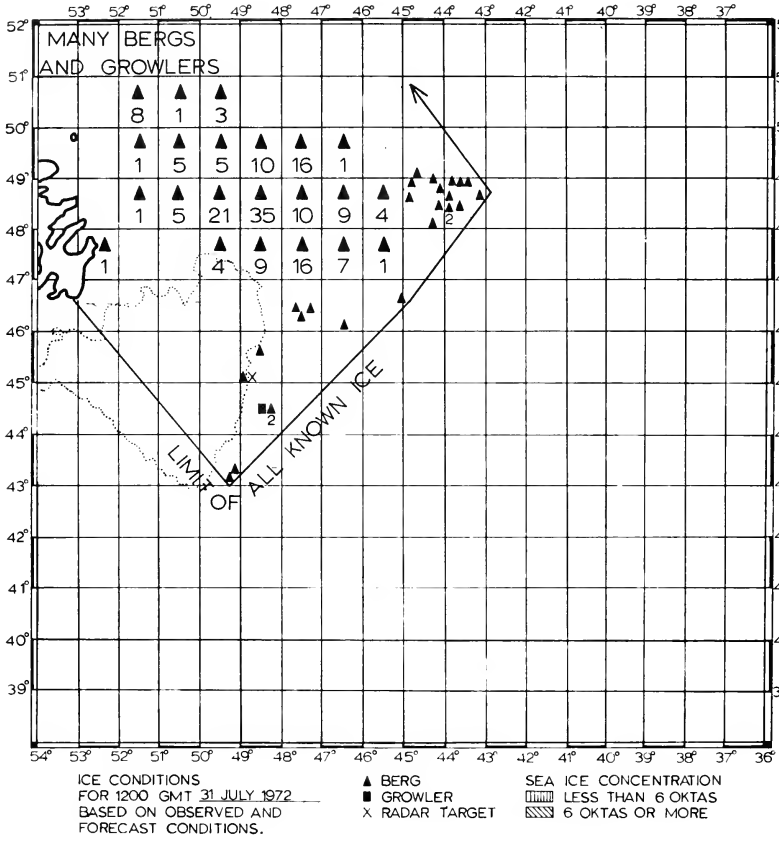

Figure 18.—Ice Conditions, 1200 GMT 31 July 1972.

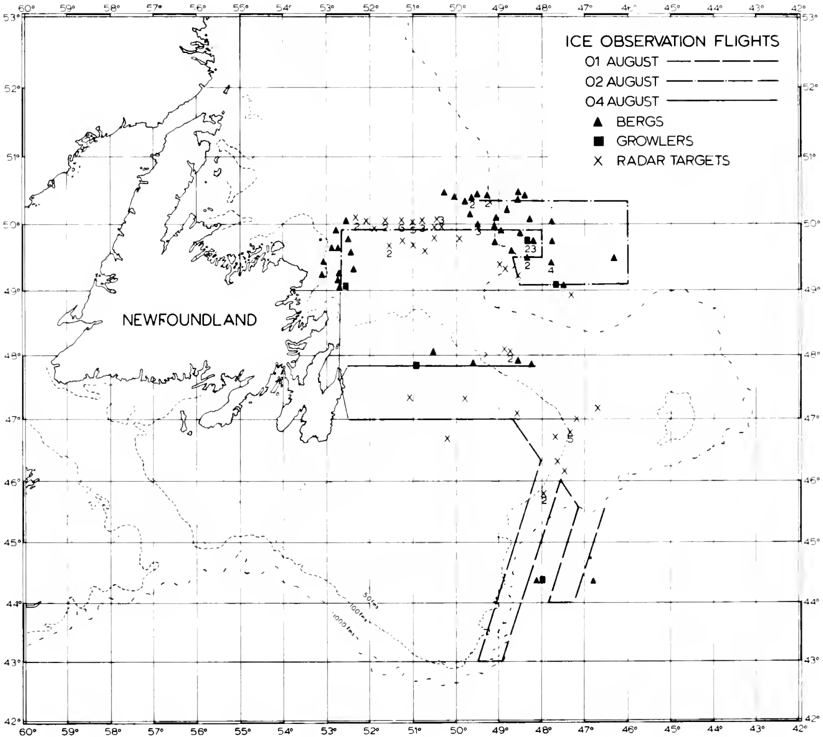

FIGURE 19.—Ice Observation Flights 1–4 August 1972.

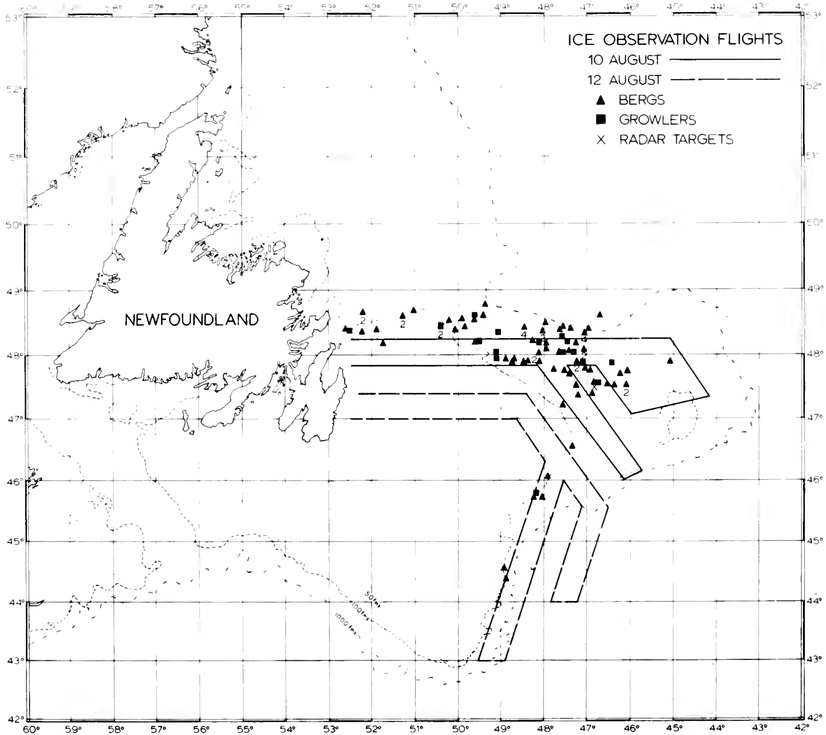

FIGURE 20.—Ice Observation Flights 10 and 12 August 1972.

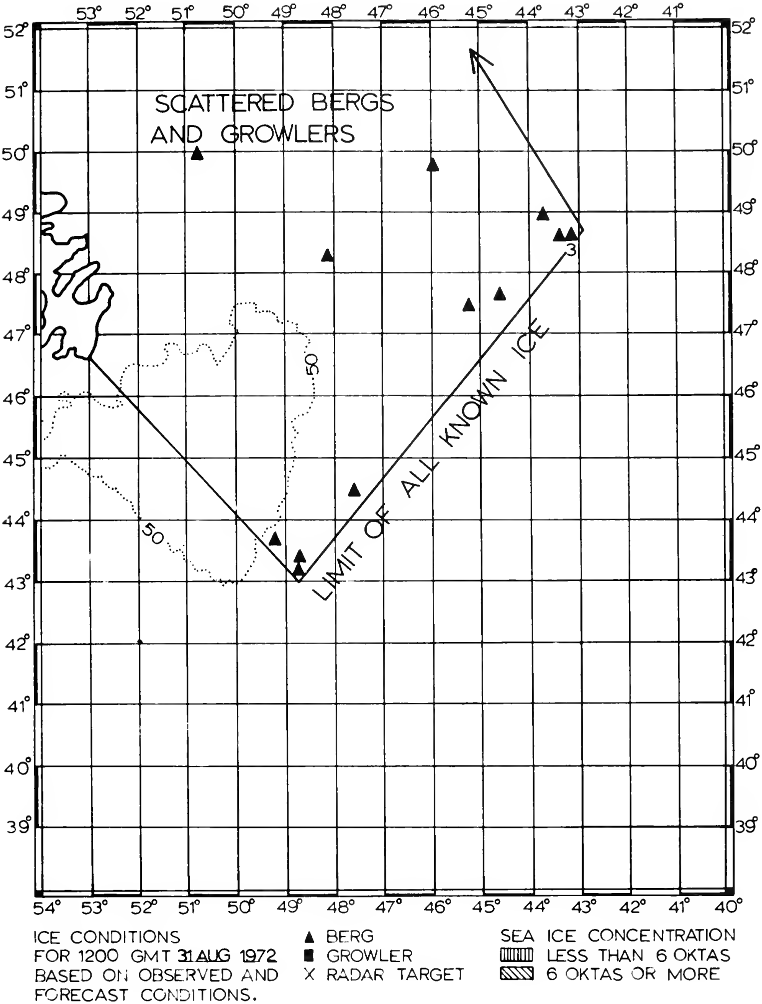

Figure 21.—Ice Conditions, 1200 GMT 31 August 1972.

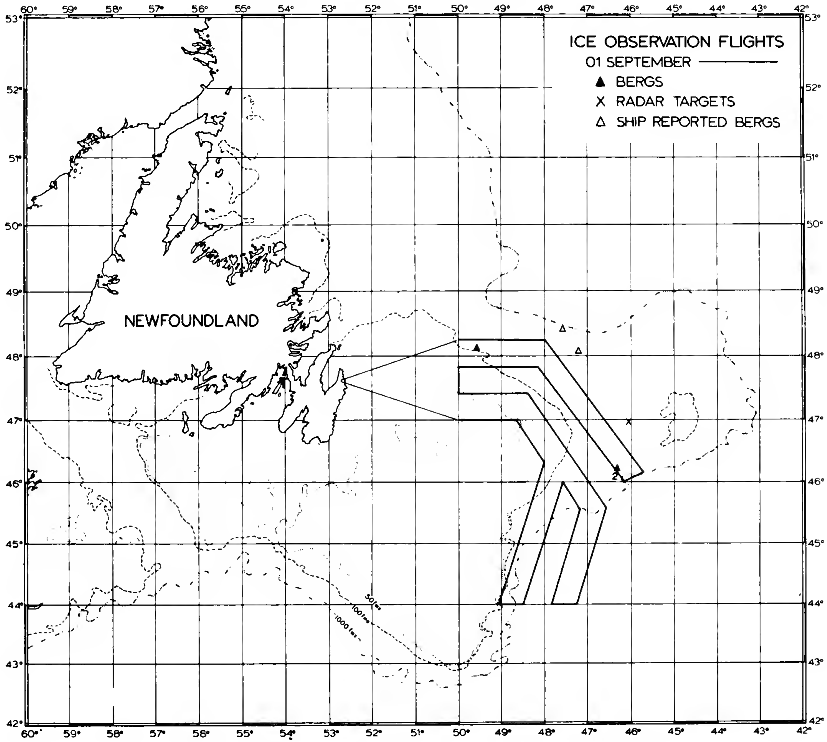

FIGURE 22.—Ice Observation Flight 1 September 1972.

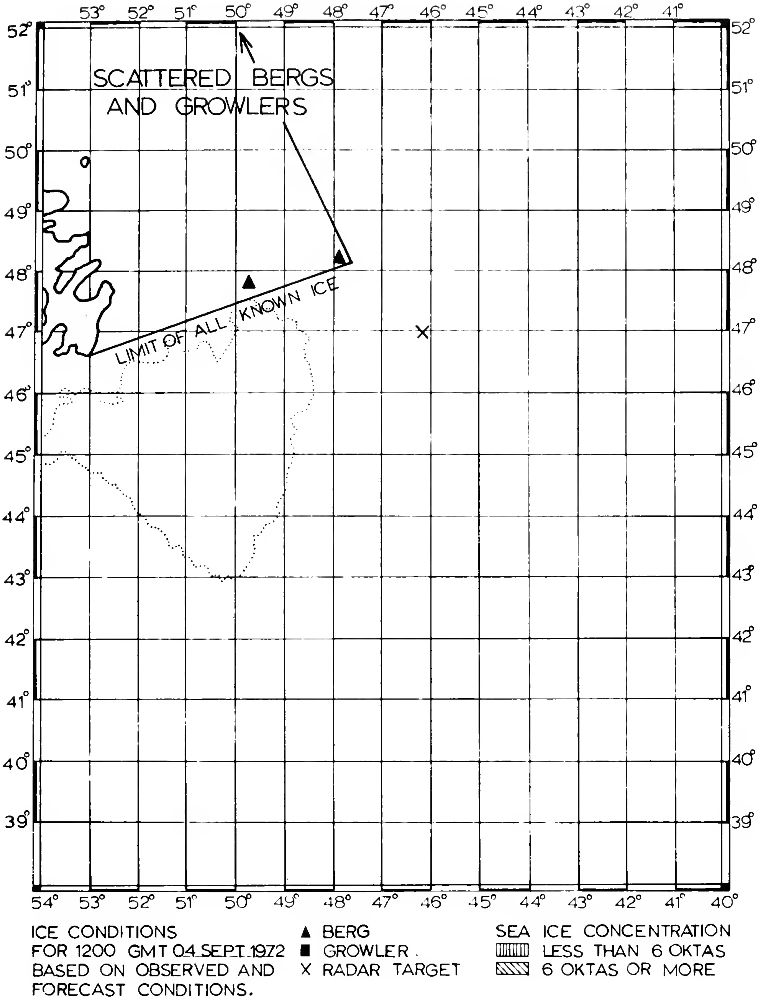

FIGURE 23.—Ice Conditions, 1200 GMT 4 September 1972.

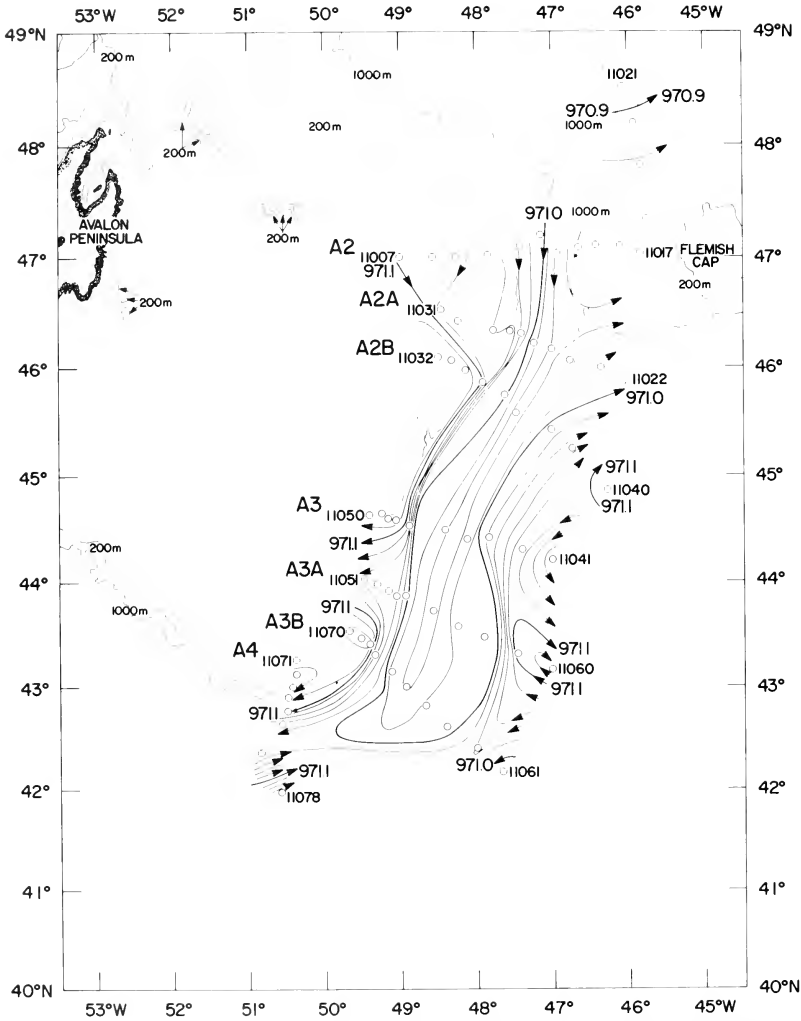

Figure 24.—Dynamic Topography of the Sea Surface with Reference to the 1000 Decibar Surface. First Cruise, April 1972.

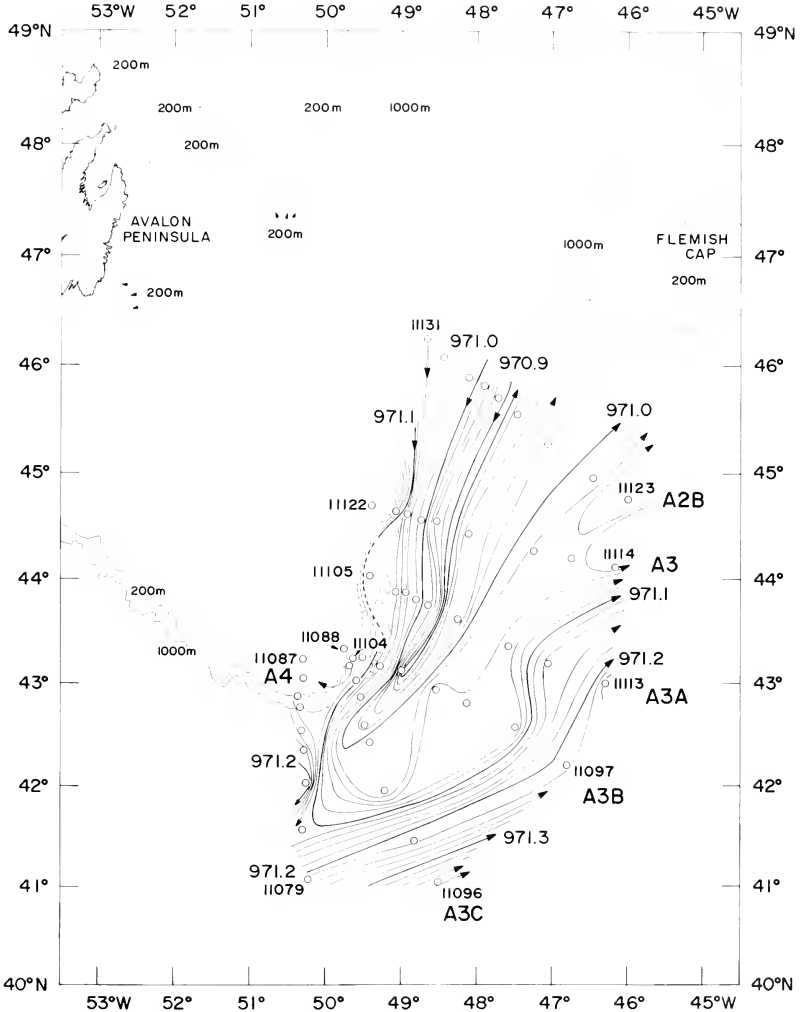

FIGURE 25.—Dynamic Topography of the Sea Surface with Reference to the 1000 Decibar Surface. Second Cruise, May 1972.

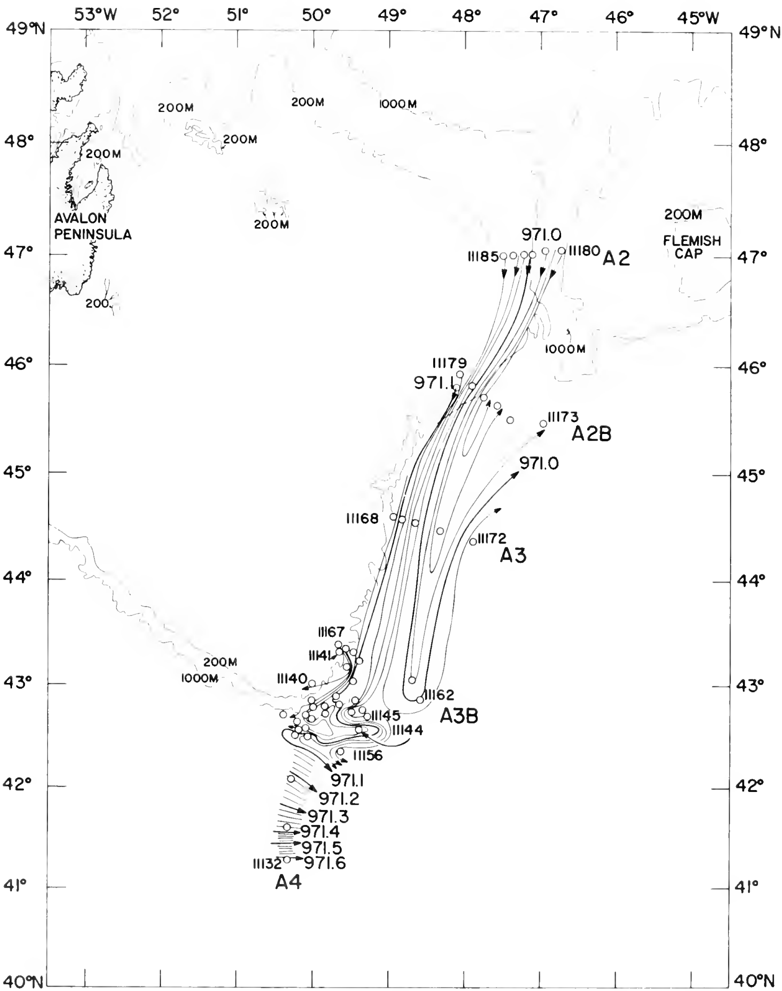

FIGURE 26.—Dynamic Topography of the Sea Surface with Reference to the 1000 Decibar Surface. Third Cruise, June 1972.

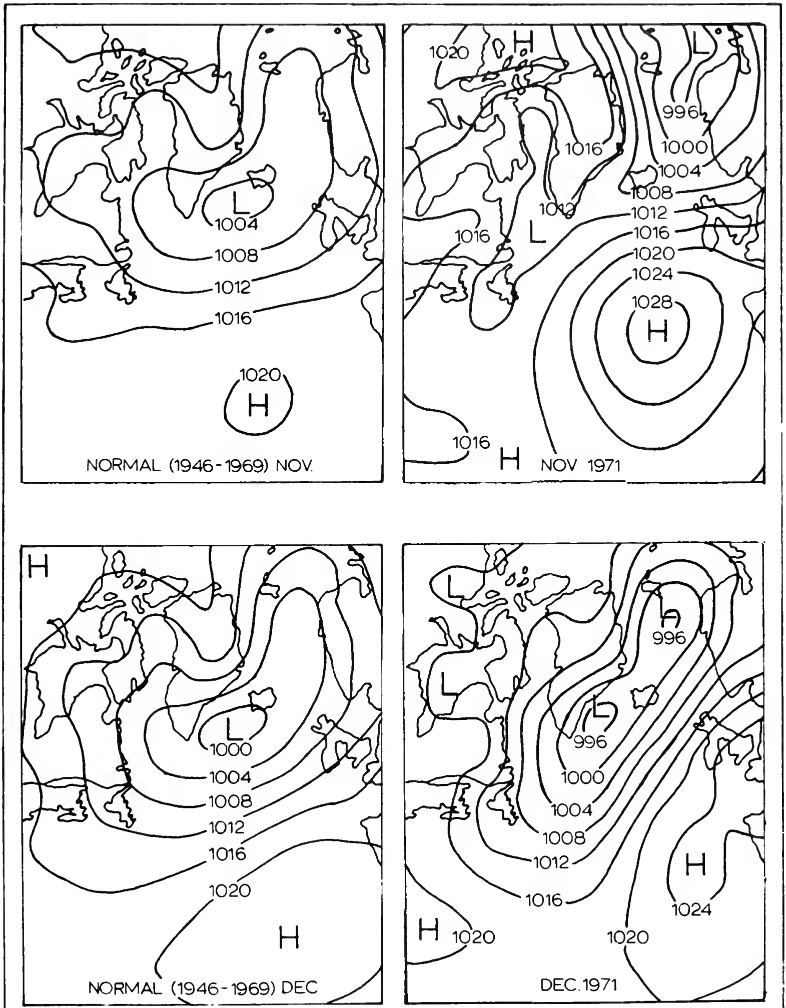

FIGURE 27a.—November and December Normal and 1971 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

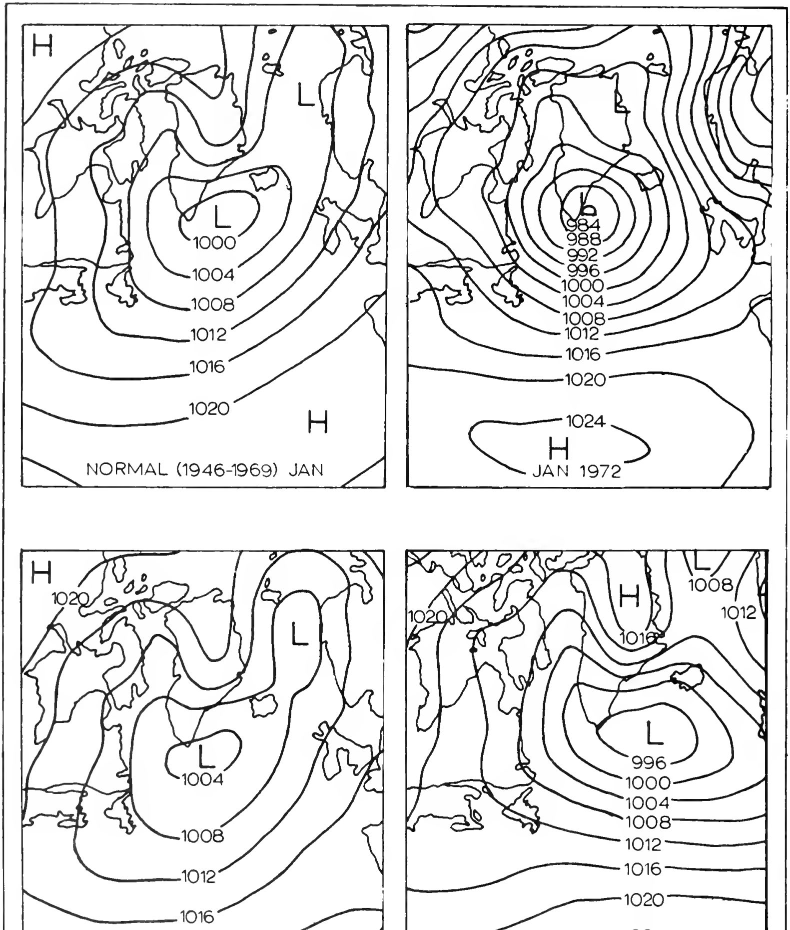

FIGURE 27b.—January and February Normal and 1972 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

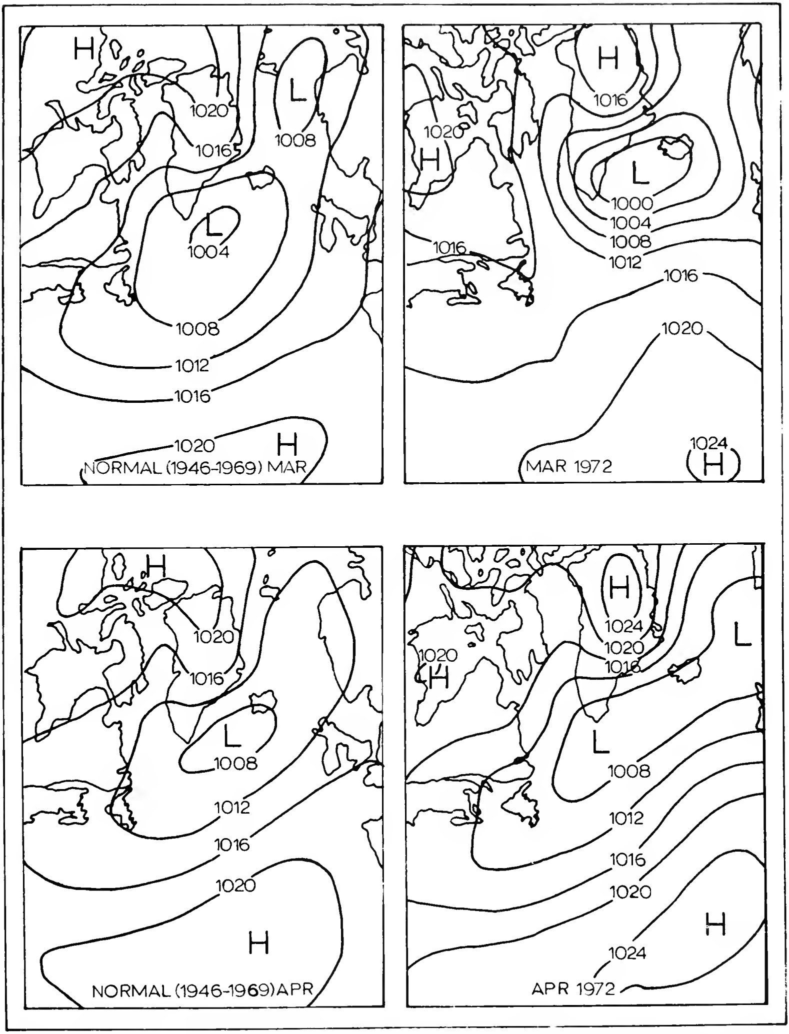

Figure 27c.—March and April Normal and 1972 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

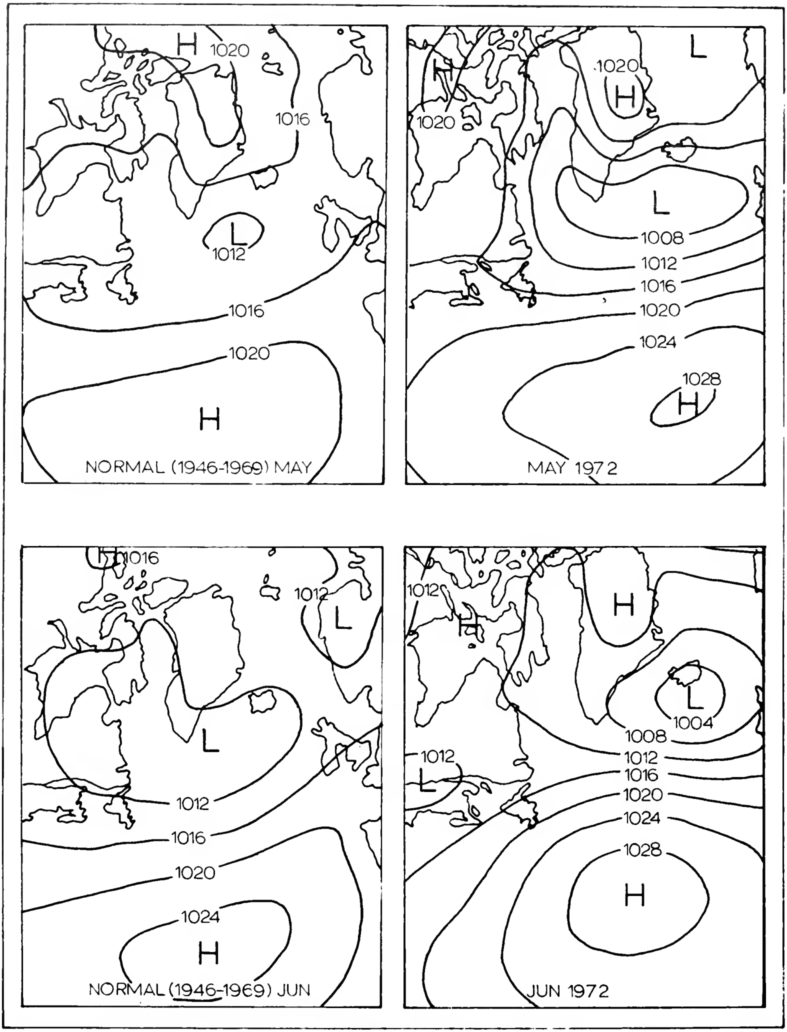

FIGURE 27d.—May and June Normal and 1972 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

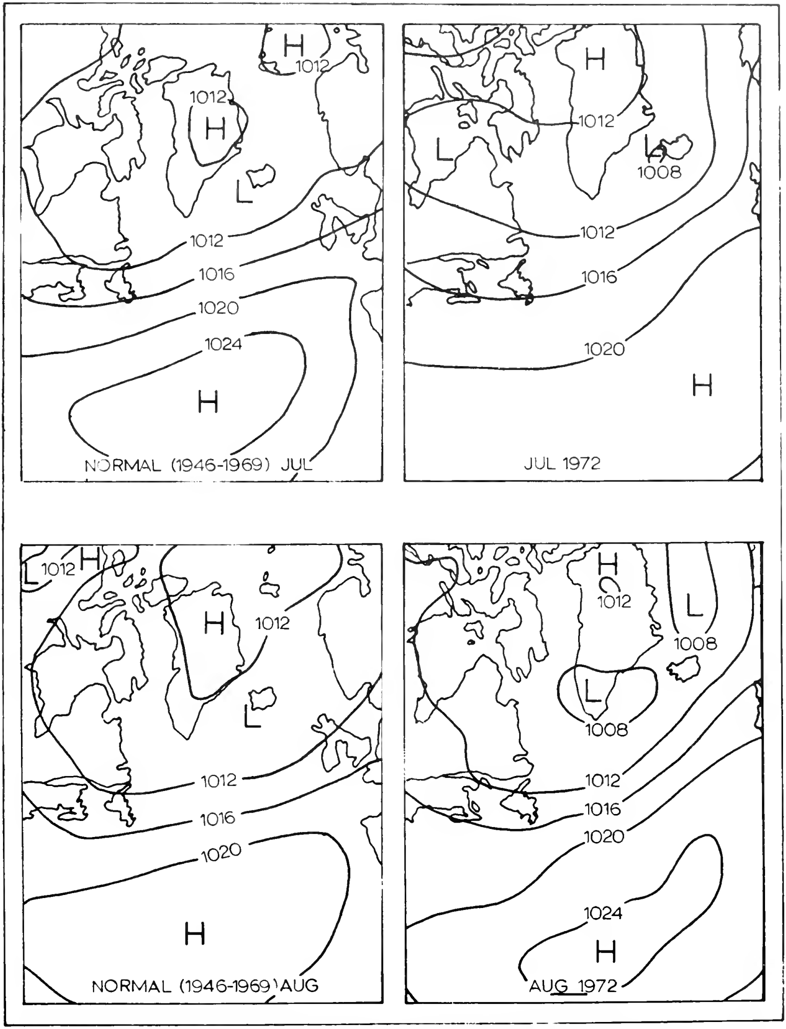

FIGURE 27e.—July and August Normal and 1972 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

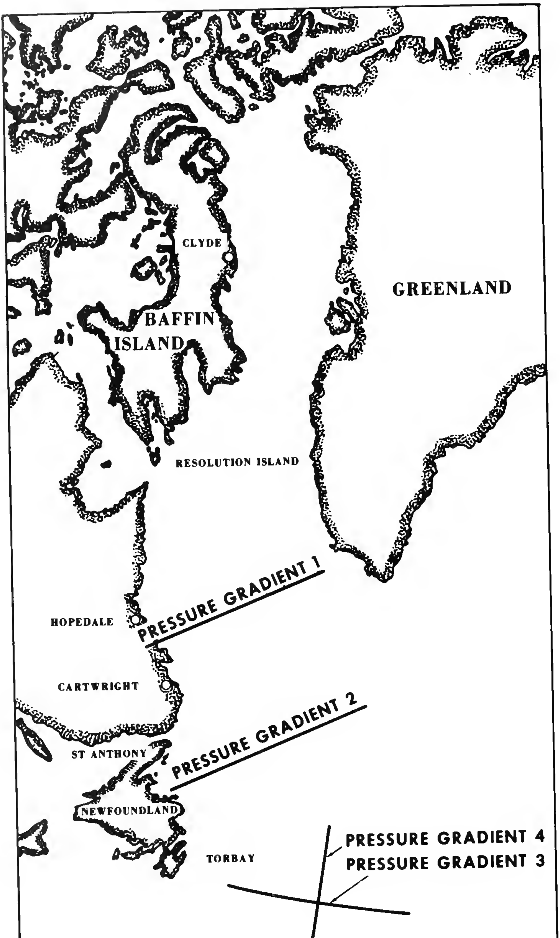

FIGURE 28.—Locater Chart.

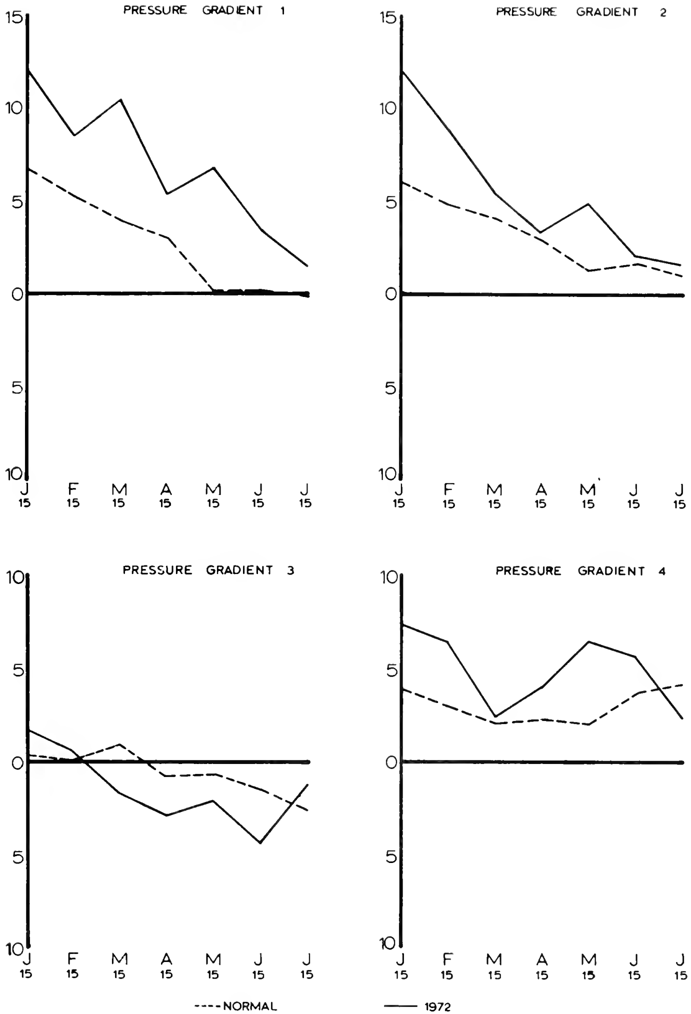

FIGURE 29.—Pressure Gradients 1–4.

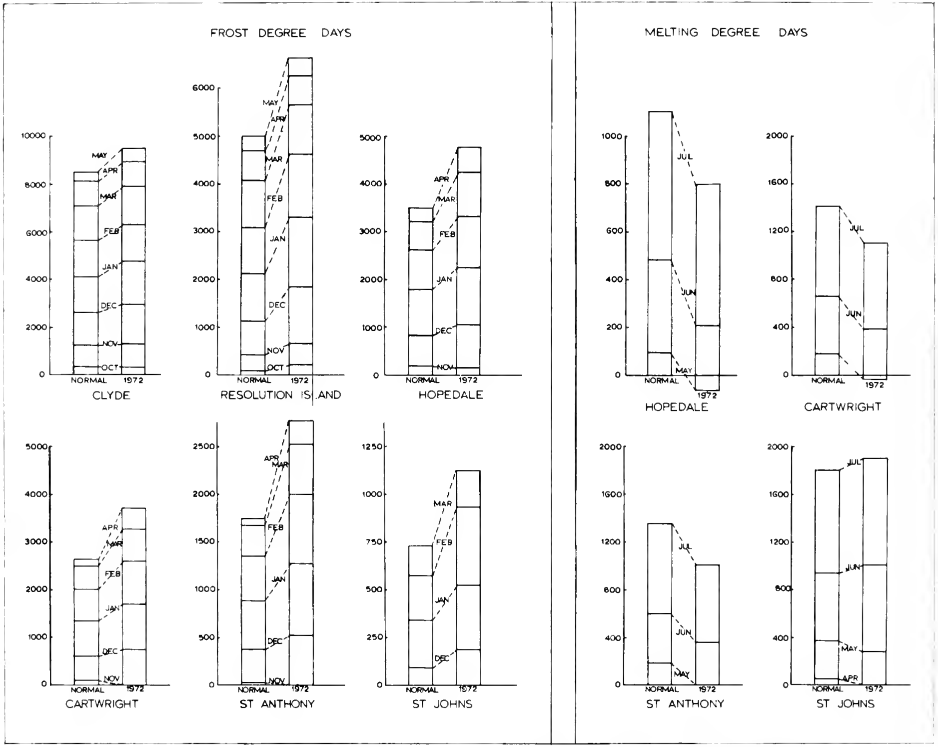

FIGURE 30—Frost Degree Day and Melting Degree Day Accumulations Calculated from Monthly Mean Fahrenheit Air Temperature.

DEPARTMENT OF TRANSPORTATION

COAST GUARD

BULLETIN NO. 59

Report of the International Ice Patrol Service in the North Atlantic Ocean

SEASON OF 1973

75 pp

CG-188-28

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MAILING ADDRESS
U.S. COAST GUARD
400 SEVENTH STREET SW
WASHINGTON, D.C. 20590
PHONE: (202) 426-1881

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Bulletin No. 59

REPORT OF THE INTERNATIONAL ICE PATROL SERVICE IN THE NORTH ATLANTIC OCEAN

Season of 1973

CG-188-28

FOREWORD

Forwarded herewith is Bulletin No. 59 of the International Ice Patrol describing the Patrol's services, and ice observations and conditions during the 1973 season.

R. H. Scarborough
Chief, Office of Operations

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PREFACE

This report is 59th in a series of annual reports on the International Ice Patrol Service in the North Atlantic Ocean. It contains information on Ice Patrol organization, communications and operations, on ice and environmental conditions and their relationship in 1973, and a listing of iceberg casualties to shipping, 1800 - 1973.

The author of this report, Lieutenant Douglas W. CROWELL, USCG acknowledges ice and weather data provided by the Canadian Department of the Environment, weather data provided by the U.S. National Weather Service, weather and oceanographic data provided by the U.S. Naval Weather Service, and oceanographic data provided by the U.S. Coast Guard Oceanographic Unit. Acknowledgement is also made to Yeoman First Class Bruce S. COLLINS, USCG, Yeoman Third Class Philip T. KEITH, USCG, Marine Science Technician First Class Neil O. TIBAYAN, USCG, Marine Science Technician Second Class Raymond J. EVERS, USCG, Marine Science Technician Third Class James M. GAYNOR, USCG, and Marine Science Technician Third Class Larry D. STARK, USCG for their assistance in the preparation of the manuscript and illustrations for this report.

The continued generosity and cooperation given by the Canadian Forces in permitting the International Ice Patrol to utilize their facilities at Summerside, Prince Edward Island is again gratefully acknowledged.

INTERNATIONAL ICE PATROL, 1973

The 1973 International Ice Patrol Service in the North Atlantic Ocean was conducted by the United States Coast Guard under the provisions of Title 46, United States Code, Sections 738, 738a through 738d, and the International Convention for the Safety of Life at Sea, 1960, Regulations 5 through 8. The International Ice Patrol is a service for observing and disseminating information on ice conditions in the Grand Banks Region of the Northwest Atlantic Ocean. During the ice season, the southeastern, southern and southwestern limits of the regions of icebergs in the vicinity of the Grand Banks of Newfoundland are guarded for the purpose of informing passing ships of the extent of this dangerous region. The International Ice Patrol also studies ice conditions in general with emphasis on the formation, drift and deterioration of icebergs, and assists ships and personnel requiring aid within the limits of operation of the Ice Patrol forces.

The International Ice Patrol is directed from the Ice Patrol Office located at the U.S. Coast Guard Base, Governors Island, New York. The Office gathers ice and environmental data from a variety of sources, maintains an ice plot, forecasts ice conditions, prepares the twice-daily Ice Bulletin, replies to requests for special ice information, and executes operational control of the Aerial Ice Reconnaissance Detachment, the Ice Patrol oceanographic cutter, and the Surface Patrol cutter when assigned.

Vice Admiral Benjamin F. ENGEL, U.S. Coast Guard, was Commander, International Ice Patrol. Captain Eugene A. DELANEY, U.S. Coast Guard, was directly responsible for the management of the Patrol.

A single pre-season flight was made in mid-January 1973. The Aerial Ice Reconnaissance Detachment was deployed to Canadian Forces Base, Summerside, Prince Edward Island on 24 January and returned to the United States on 28 July 1973.

The 1973 Ice Season officially commenced at 0000 GMT, 24 January, when the first Ice Bulletin was issued, and continued until the final Bulletin was issued at 0000 GMT, 31 July 1973. The twice-daily Ice Bulletins were broadcast by the International Ice Patrol Communications Station Boston/NIK, U.S. Naval Radio Station Norfolk/NAM, Canadian Maritime Command Radio Station Mill Cove/CFH, and Canadian Coastal Radio Station St. John's/VON. The Ice Bulletin was

included in the U.S. Marine Information Broadcast for the High Seas of the North Atlantic, a voice broadcast originating from the U.S. Coast Guard Communications Station Boston/NMF. A facsimile ice chart was broadcast from Boston once each day. Iceberg information was also included on the regularly scheduled radio facsimile broadcasts of Naval Radio Norfolk/NFAX, CANMARCOM/CFH, Radio Bracknell/GFE, Radio Hamburg/DGC and Radio Quickburn/DGN.

The U.S. Coast Guard Cutter EVERGREEN, Commanded by Lieutenant Commander Martin J. MOYNIHAN, U.S. Coast Guard, conducted oceanographic cruises for the Ice Patrol during 3 - 26 April, 8 - 29 May and 13 June - 14 July. Approximately 13 days of the final cruise were devoted to a special survey that provided field data and verification to the Labrador Current model developed by Commander Ronald C. KOLLMEYER, U.S. Coast Guard. This may become a useful input to the iceberg drift program.

For the second consecutive year a surface patrol was required. USCGC HAMILTON, commanded by Captain James H. SWINT, U.S. Coast Guard, assumed the first Surface Patrol duties on 10 March while enroute home port after completing Ocean Station CHARLIE duties. HAMILTON was relieved on 17 March and the following cutters continued the surface patrol:

USCGC DECISIVE — 17 - 31 March; 13 - 29 June
Commanded by Commander John B. EKMAN, U.S. Coast Guard

USCGC ALERT — 31 March - 11 April
Commanded by Commander Robert C. NICHOLS, U.S. Coast Guard

USCGC STEADFAST — 11 - 24 April; 2 - 5 May
Commanded by Commander Royce R. GARRETT, U.S. Coast Guard

USCGC OWASCO — 24 April - 2 May; 21 - 26 May
Commanded by Commander Robert G. MOORE, U.S. Coast Guard

USCGC DEPENDABLE — 5 - 21 May; 26 May - 1 June
Commanded by Commander Richard D. THOMPSON, U.S. Coast Guard

USCGC VIGOROUS — 1 - 13 June
Commanded by Commander Richard W. MICHAELS, U.S. Coast Guard

USCGC MENDOTA — 29 June - 10 July
Commanded by Commander Robert GILLESPIE, U.S. Coast Guard

On 10 July, with icebergs no longer a threat below 44°N, the surface patrol was terminated.

During the 1973 Season an estimated 847 icebergs drifted south of 48°N, a heavy season that was equal in length to last years record of 189 days.

AERIAL ICE RECONNAISSANCE

During the period 5 September 1972 to 31 August 1973 a total of 83 ice observation flights were flown. Pre-season flights made in January accounted for 6 flights, and the remaining 77 flights were made during the ice season. There was no requirement for any post-season flights. The objective of the pre-season survey was to study the iceberg distribution patterns in the Labrador Sea and to evaluate the iceberg potential of the developing ice season. The season flight objectives were to locate the southwestern, southern, and southeastern limits of icebergs, to evaluate the short term iceberg potential of the waters immediately north of the Grand Banks, and occasionally to study the iceberg distribution along the Labrador Coast. The flight statistics shown in Table 1 do not include the flight time required to make the passages between U.S. Coast Guard Air Station, Elizabeth City, North Carolina and the operating bases for crew relief or aircraft maintenance.

Table 1 - Aerial Ice Reconnaissance Statistics
September 1972 to August 1973

Month		Number of Flights	Flight Hours
PRESEASON			
September-December		0	0
January		6	34.2
	Preseason total	6	34.2
SEASON			
January		4	28.0
February		10	54.9
March		14	94.5
April		12	83.6
May		17	113.5
June		11	65.3
July		9	44.7
August		0	0
	Season total	77	484.5
	Annual total	83	518.7

Aerial ice reconnaissance was accomplished by U.S. Coast Guard HC-130-B (Lockheed Hercules) four-engine aircraft from the Coast Guard Air Station at Elizabeth City, North Carolina. During the iceberg season, the aircraft operated out of Canadian Forces Base Summerside, Prince Edward Island; Torbay Airport, St. John's Newfoundland; and Gander Airport, Newfoundland.

On 24 January the Ice Reconnaissance Detachment deployed to Summerside from Elizabeth City. Occasionally, during periods of good visibility, the aircraft operated from St. John's or Gander. Although these Newfoundland airports are some 500 miles closer to the Grand Banks than Summerside, the overall cost of lodging and fuel, as well as the outstanding services offered by the Canadian Forces Base at Prince Edward Island made it economical to return there at most opportunities. The main base remained at Summerside until 28 July when the Detachment returned to the United States.

COMMUNICATIONS

Ice Patrol communications included ice reports, environmental conditions, Ice Bulletins, special ice advisories, a daily facsimile chart, and the administrative and operational traffic necessary to the conduct of the Patrol. The Ice Bulletin was transmitted by teletype from the Ice Patrol Office in New York twice each day to over 30 addressees, including those radio stations which broadcast the Bulletin. These stations were the U.S. Coast Guard Communications Station Boston/NIK/NMF, U.S. Naval Radio Station Norfolk/NAM, Canadian Coastal Radio Station St. John's/VON and Canadian Forces Maritime Command Radio Station Mill Cove/CFH.

Coast Guard Communications Station Boston transmitted the Bulletin by CW at 0018 GMT on 5230 and 8502 kHz and at 1218 GMT on 8502 and 12750 kHz. After a 2-minute series of test signals the transmissions were made at 25 words per minute and then repeated at 15 words per minute. An abbreviated version of the Ice Bulletin was included in the Western North Atlantic High Seas Broadcast (voice) from Boston on 8765.4 (8764.0) kHz upper side band mode at 0130, 0730, 1330 and 1930 GMT and on 8764.0 kHz double side band mode at 0200, 0800, 1400 and 2000 GMT. During the season a statement was included in every fourth day's voice broadcast requesting comments on the usefulness of presenting ice information in this manner. No replies were received from the maritime community, thus it is anticipated that the use of the Western North Atlantic High Seas Broadcast for dissemination of Ice Patrol information will be discontinued. Coast Guard Communications Station Boston/NIK also transmitted a daily radiofacsimile broadcast depicting the locations of icebergs and sea ice at 1600 GMT simultaneously on 8502 and 12750 kHz at a drum speed of 120 revolutions per minute.

Special broadcasts were made by Canadian Coastal Radio Station St. John's/VON as required when icebergs were sighted outside the limits of ice between regularly scheduled broadcasts. These transmissions were preceded by the International Safety Signal (TTT) on 500 kHz.

Merchant ships calling to transmit ice sightings, weather and sea surface temperatures were requested to use the regularly assigned international call signs of the Coast Guard Ocean Stations, East Coast AMVER Radio Stations, or Canadian Coastal Radio Station St. John's/VON. All Coast Guard Stations were alert to answer NIK/NIDK calls, if used.

Ice information services for the Gulf of St. Lawrence, as well as the approaches and coastal waters of Newfoundland and Labrador, were provided by the Canadian Department of the Environment from December until approximately late June. Ships obtained ice information by contacting the Ice Operations Officer, Sydney, Nova Scotia via Sydney Marine Radio/VCO or Halifax Marine Radio/VCS.

Communications statistics for the period 5 September 1972 through 31 August 1973 are shown in Table 2.

Table 2 - COMMUNICATIONS STATISTICS

Number of ice reports received from ships	842
Number of ships furnishing ice reports	317
Number of ice reports received from commercial aircraft .	37
Number of sea surface temperature reports	381
Number of ships furnishing sea surface temperature reports.	100
Number of ships requesting special ice information . . .	33
Number of NIK Ice Bulletins issued	378
Number of NIK facsimile broadcasts	188

Of the one-hundred ships furnishing Ice Patrol with special sea surface temperature observations, the ten most outstanding contributers were:

M/V Atlantic Span/SLPN
M/V Scandic Wasa/SMIK
M/V Transamerica/DHPT
M/V Leonardo Da Vinci/ICLN
M/V Ivo Vojnovic/YTEI
USCGC SHERMAN/NMMJ
M/V Ritva Dan/OZBM
M/V Banija/YTEK
M/V Hilla/GRHT
M/V St. Margaret/GHJM

TABLE 3 - Estimated Number of Icebergs South of Latitude 48°N, Season of 1973

	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	TOTAL
1973	4*	0	0	6	54	110	134	212	159	151	19	1	850(847)
Total 1946-1973	9	2	4	11	64	237	895	2563	2257	1444	313	39	7,838
Average 1946-1973	0	0	0	0	2	9	32	92	81	52	11	1	280
Total 1900-1973	255	109	110	91	184	688	2997	7408	9340	4962	1509	428	28,081
Average 1900-1973	3	1	2	1	3	9	41	100	126	67	20	6	379

*Three(3) of these icebergs actually drifted south of 48°N during the 1972 Ice Season; however, they are listed here to provide statistical continuity.

ICE CONDITIONS, 1973 SEASON

September

When the 1972 Ice Season officially closed on 4 September, three icebergs had already drifted south of 48°N. The computer plot was maintained and no further intrusion of icebergs occurred south of 48°N until 19 September when an iceberg was reported in position 47°50'N 39°45'W. A total of seventeen other icebergs were reported during September, mostly in the Strait of Belle Isle, its eastern approaches, and along the coast of Labrador.

October - November

During October, 29 icebergs were reported to the Ice Patrol Office located from the Strait of Belle Isle northward. November, however, showed 4 of its 33 iceberg reports to be south of the Strait. The southernmost of these was reported to be in position 50°50'N 53°11'W on 11 November.

December

Only 17 iceberg reports were received, but there were several significant sightings: one of 24 December off Cape Spear, Newfoundland and two icebergs off Cape Race on 30 December. It was estimated that 6 icebergs drifted south of 48°N during this month. These reports prepared the Ice Patrol office for what was to be its earliest commencement date in history and are attributable to the very early sea ice cover which developed along the Labrador coast and in the Strait of Belle Isle. The rapid growth and drift of sea ice in the vicinity of St. John's continued during the month with its eastern limit near 50°W by the end of December.

January

Icebergs continued to move south and sea ice continued its rapid growth spreading southeastward throughout the northern portion of the Grand Banks during the first two weeks of January, extending to 46°30'N 46°W. An offshore wind induced drift component kept the heavier ice away from the coast south of Fogo Island but there was now sea ice in most of Newfoundland's bays. Close pack ice in the transitional stage from Grey-White to First Year ice blocked the approaches to Notre Dame Bay west of Fogo Island. During the period 9 - 19 January a preseason survey was made along the Labrador and

Baffin Island coasts and the waters east of Newfoundland. The flight tracks and observed icebergs are shown in figure 1. The area south of Hamilton Inlet, normally iceberg free in early January, had an extremely high concentration of 264 icebergs, seven of which were south of 48°N. Northward to Hudson Strait only 64 icebergs were sighted, 5 less than normal. Between Hudson Strait and just north of Cape Mercy, Baffin Island only 53% of the 251 iceberg normal distribution was observed, however, over 3 times the normal amount of icebergs were counted in Davis Strait. The latitudinal distribution is illustrated graphically in figure 2. On the basis of this preseason survey plus seven additional ship reports of icebergs south of 48°N, Ice Patrol forces were deployed to Canadian Forces Base, Summerside, Prince Edward Island and services were initiated on 24 January, the earliest commencement date in Ice Patrol history. The initial ice reconnaissance flights on 25, 27 and 28 January located a total of 66 bergs, 13 growlers and 18 radar targets as shown in figure 3. The southernmost iceberg of this month reached 44°52'N 47°30'W on 28 January. Meanwhile ships continued to report icebergs far to the southeast of Flemish Cap, reaching the easternmost limit of the month at 46°07'N 41°02'W on 30 January as shown in figure 4. It was estimated that a total of 54 icebergs drifted south of 48°N during January.

February

The southern and eastern limits of sea ice off the coast of Newfoundland receded during February to where the southern edge of the heavy pack ice at the end of the month lay north of 48°N. During the first eighteen days of the month, only four observation flights were conducted due to poor on scene weather generated by predominant southwesterly winds. These winds also prevented any significant southerly iceberg movement and promoted an eastward dispersal towards Flemish Cap, distributed northward as shown in figure 5. Of significance in this same figure is that the northern portion of the Grand Banks is relatively iceberg free, which lessened the iceberg threat for the remainder of the month. Figure 6 shows the sea ice conditions as well as the southernmost and easternmost icebergs of the month, which both occurred on 28 February. They had drifted to positions 44°06'N 48°51'W and 46°47'N 38°32'W, respectively. It is estimated that 110 icebergs drifted south of 48°N during February, 22 times the monthly average.

March

At the begining of March, new ice had spread southward to near 47°30'N 47°W and in the coastal area to near Cape Race. Iceberg drift continued to be southerly and easterly until the easternmost iceberg of the season reached 46°52'N 37°59'W before melting on 6 March. The ice conditions at this time are shown in figure 7. Ice observation flights on 7, 8 and 11 March located a total of 36 bergs, 12 growlers and 5 radar targets as shown in figures 8 and 9. With icebergs already south of the Tail of the Banks, a Surface Patrol was started on 10 March. The iceberg conditions on 11 March as shown in figure 10 had the southernmost iceberg for the month in position 41°23'N 48°31'W. By mid-March the pack ice extended from Cape Freels to near 45°30'N 46°30'W to 47°40'N 45°W and then northwestward. During the second half of March, mean northerly winds east of Newfoundland caused the sea ice to drift southward and carried it past St. John's, blocking access to this harbor for much of the period. A tongue of ice drifted around the eastern edge of the Grand Banks and by the end of March extended south to near 44°50'N. Ice observation flights on 24, 28 and 29 March, as shown in figure 11, located a total 234 icebergs. A flight on 31 March north of the Strait of Belle Isle to Hamilton Inlet located an additional 74 bergs. These indicated a potential of over 300 icebergs to intrude upon the Grand Banks during the next six to eight weeks. During the month of March, an estimated 134 icebergs drifted south of 48°N.

April

During early April concentrations of sea ice below 48°N showed some signs of deterioration; however, the southern tongue of open pack ice extended as far south as 43°30'N on 3 April as shown in figure 12. By mid-April the central pack (6 oktas or more) had moved southward to 45°N, with little change to the extent of the tongue of sea ice. Ice observation flights on 17 and 18 April (figure 13) revealed iceberg concentrations on the northeast corner of the Grand Banks along the eastern slope, a distribution ideal for maximum southward iceberg movement. Before the end of the month, a strong northerly wind had packed ice onto the coast from the Avalon Peninsula to Belle Isle. North of latitude 49°N, the ice edge retreated westward, but over the northern Grand Banks area the sea ice extended eastward to near 48°W, some 150 miles beyond its average limit. These conditions brought the southernmost iceberg of the month to 40°40'N 49°04'W by the end of April These sea ice and iceberg conditions are shown on figure 14. During April an estimated 212 icebergs drifted south of 48°N.

May

Continued northeasterly winds promoted more southerly iceberg drift. A ship report of two icebergs west of 40°W extended the limits of all known ice to encompass over 250,000 square miles south of 48°N on 7 May, as shown in figure 15. This date also represented the southernmost iceberg of the season at 39°46'N 50°W as well as the easternmost bergs of the month, two at 42°41'N 39°27'W. On 5 May a ship reported the southernmost ice for the season, a growler in position 37°12'N 49°W or some 1250 miles due east of the Virginia coast. After the first week of May, offshore wind induced drift developed along the coast of Newfoundland, loosening the sea ice south of latitude 49°N and developing leads along the coast, finally reopening St. John's harbor. Ice observation flights on 14, 15 and 17 May (figure 16) located a total of 123 icebergs, 6 growlers and 64 radar targets concentrated on the Grand Banks and its eastern slope. For the remainder of the month, the average surface winds were from the southwest over the Grand Banks, contributing no significant southward iceberg drift and lessening the iceberg threat to mariners crossing south of the Tail of the Banks. By the end of the month, sea ice remained along the Newfoundland coast from Cape Freels to the Strait of Belle Isle. The Strait was clear of sea ice and open to unrestricted marine traffic on 30 May. It is estimated that 159 icebergs drifted south of 48°N during this month.

June

Iceberg conditions on the first of June (figure 17) were still very serious with 344 icebergs on plot south of 48°N (155 bergs south of 46°N) many of which had crossed this parallel during April and not yet deteriorated. Ice reconnaissance flights on 7 and 8 June covered the area between 47°N and 50°N to give an indication of the iceberg potential for the remainder of the month. This area was last flown on 14 May and was not reflown due to the prevailing fog conditions. Figure 18 shows the 137 icebergs, 10 growlers and 10 radar targets located on these flights indicating that, in spite of the early commencement, Ice Patrol would continue for at least another month. Sea ice rapidly receded within Notre Dame Bay until it became clear by mid-month. Mid-June also had the southernmost and easternmost icebergs for the month located in positions 42°02'N 48°14'W (15 June) and 44°52'N 41°25'W (18 June), respectively. A good sequence of ice observation flights on 19, 20 and 21 June (figure 19) revealed only 58 icebergs, 14 growlers and 4 radar targets, however, with icebergs still south of the Tail of the Banks, the Surface Patrol was continued. During June 151 icebergs were estimated to have drifted south of 48°N.

July

The iceberg condition in the begining of July, as shown in figure 20, still had 76 icebergs south of 48°N. With four radar targets at the Tail of the Banks, the Surface Patrol continued until the fog lifted and subsequent searches by the Coast Guard cutter failed to locate any ice. Thus on 10 July, with icebergs no longer a threat south of 44°N, the Surface Patrol was terminated. Intermittent ice observation flights throughout the month, limited due to on scene weather, monitored the retreating iceberg limits. Then on 25 and 26 July flights with very good visibility failed to locate any icebergs. The four icebergs on figure 21 were reported by a ship subsequent to the 26 July flight and were the only icebergs remaining in the vicinity of the Grand Banks to threaten North Atlantic shipping. These bergs subsequently drifted south of 48°N before melting during the first week of August. Thus notification was given the maritime community and Ice Patrol services ended on 31 July. During this month an estimated 19 additional icebergs drifted south of 48°N.

August

Although the Ice Patrol services had officially terminated, the Ice Season terminates on 31 August for statistical purposes with the new season begining 1 September. During the remainder of the month many iceberg reports were received from ships approaching the Strait of Belle Isle, the southernmost of which were two icebergs located just south of 51°N on 28 August. One berg drifted south of 48°N during August which brought the statistical total for the 1973 season to 847 icebergs (plus 3 which were left over from the 1972 season).

OCEANOGRAPHIC CONDITIONS, 1973

Three oceanographic cruises during the periods 3-26 April, 8-29 May and 13 June - 14 July were conducted by the U.S. Coast Guard Oceanographic Unit in support of the International Ice Patrol aboard USCGC EVERGREEN (WAGO 295). Approximately 13 days of the final cruise were devoted to special surveys that provided field data and verification to a Labrador Current model, developed by Commander Ronald C. KOLLMEYER, USCG. Salinity and temperature data were collected to a depth of at least 1000 meters (bathymetry permitting) using a Salinity-Temperature-Depth (STD) Sensor System. Data were recorded on magnetic tape using a digital data logger for further processing upon return to the Coast Guard Oceanographic Unit, Washington, D.C. From processed data, charts of dynamic topography of the sea surface relative to an assumed 1000 decibar level of no motion were constructed (figures 22-27). Only the 7-22 April and 1-4 July dynamic topography charts show the prominent features of the general circulation pattern on the Grand Banks. The Labrador Current can be seen slowing southward along the eastern slope of the Grand Banks near the 1000 meter depth contour. To the east is a dynamic trough separating the colder Labrador Current from the opposite flowing North Atlantic Current.

The April survey (figure 22) shows the dynamic trough just east of the Labrador Current separated into two dynamic lows as a result of the North Atlantic Current, an interesting phenomenon not shown on the average or normal dynamic topography for the month. This intrusion lessened the velocity of the core of the Labrador Current in the vicinity of 45°N to less than half its normal of about 35 cm/sec, yet at 150 kilometers north and south of this location, average velocities were determined.

The survey area in May as shown in figure 23 was apertured with anomalous dynamic highs. Associated geostrophic currents exceeded 50 cm/sec in the vicinity of 45°N 48°W where a dynamic trough is normally located. Evidence of a portion of the Labrador Current is present on the southeast corner of the Grand Banks, however, its presence further north along the 1000 meter contour is weakly defined at best. The North Atlantic Current in the eastern portion of the survey area was approximately in its normal location. Its velocities approached 100 cm/sec or approximately twice their average values.

The 1-4 July survey of 3 oceanographic sections (figure 24) compared reasonably well with the June normal dynamic topography chart, thus the previous month's average current values were assumed in the entire Grand Banks area and continued for the remainder of July.

The remaining figures (25-27) are 60-mile squares of concentrated oceanographic stations for the previously mentioned Labrador Current model. The resulting dynamic topography is very detailed, as expected, and does not compare well with either the June normal nor the contours obtained from the much wider spaced stations surveyed 1-4 July. They do point out three very important factors. First, the closer the oceanographic stations, the greater the detail, but the smaller the area that can be surveyed in the same amount of time. Second, the greater the station spacing, the larger the area that can be surveyed, but the dynamic contours are more averaged - producing a chart with less defined features. Finally, each of these special surveys exhibits different dynamic contours, and although they are spaced only four days apart, they indicate a rapidly changing surface current structure.

The above discussion was based on preliminary data collected during the surveys. A more detailed analysis of the oceanographic conditions of the Grand Banks in 1973, including water temperatures, geostrophic currents, and volume transport will be published in the U.S. Coast Guard Oceanographic Report series, CG-373.

DISCUSSION OF ICEBERG AND ENVIRONMENTAL CONDITIONS

1973 ICE SEASON

After last year's heaviest iceberg season record of 1587 bergs south of 48°N, the 1973 season total of 847 seems small, yet is still almost four times the 1946-1972 normal! Thus the contributing factors, including the number of icebergs available to drift south of 48°N latitude, the strength and duration of the northwesterly winds producing a southerly iceberg transport, the development of the features of the Labrador Current (already discussed in the Oceanographic Conditions, 1973 section), and the deterioration of icebergs are analyzed in the following paragraphs.

The January pre-season iceberg survey previously refered to in figure 1, although presenting an obvious requirement to start an early season with 264 icebergs south of Hamilton Inlet, did not allow for more than a normal potential of iceberg severity for the remainder of the ice season, considering an iceberg drift of 10-15 miles per day along the Labrador Coast. However, under unusual conditions with a very strong northwesterly wind it is possible for iceberg drifts of 24 or more miles per day to occur. At this point it is sufficient to say that a January pre-season iceberg count only as far north as Cape Dyer from the Strait of Belle Isle is inadequate and future surveys will have to be made further north along the Baffin Island coast to obtain a total potential iceberg count for the ice season.

Figure 28a. shows the November 1972 Icelandic Low located approximately 700 miles northeast of Keflavik (over 1000 miles east of its normal position in the Denmark Strait), with a mean pressure of 994 mb. A major trough extended west-southwestward from the Low, across Iceland to the southern tip of Greenland. A second major trough extended from the tip of Greenland, southward, and then southwestward to the U.S. East Coast. This easterly shift of the major pressure center resulted in winds from the north, rather than the northeast in the vicinity of Davis Strait, but with little change in magnitude. This would allow southerly movement at an average rate without grounding on the Baffin Island coast.

December of 1972 as shown in figure 28b. has the Icelandic Low positioned at 62°N 30°W, slightly east of its normal location. Its mean pressure was 985 mb, significantly lower than the normal of 1000.7 mb. This resulted in a 18 mb. tighter gradient between the center of the Low and the Labrador coast and the impedous to push icebergs further south than normal.

In figure 28c. the January Icelandic Low is again dominant, in its mean position near Cape Farewell (Kap Farvel), but with a 985 mb. pressure remaining significantly below its normal. As last month, the pressure gradients were greater than the climatological mean. The climatic normal for February as shown in figure 28d. has the Icelandic Low near 59°N 39°W (about 150 miles southeast of Cape Farewell) at 1004 mb. The actual sea level pressure was quite different. The main center of the Icelandic Low was far to the northeast, over the Norwegian Sea near 71°N 13°E at 992 mb. In what can be interpreted as a secondary center, just off Keflavik, Iceland, the pressure was 998 mb. A sharp ridge of low pressure extended from this secondary center southward over Newfoundland. Although the resulting pressure gradients were again greater than normal, they were significantly less than the previous two months.

In figure 28e. the March Icelandic Low was located between Cape Farewell and Iceland, only about 300 miles northeast of its usual 1004-mb. position and 4 mb. lower than normal. However, when combined with a 1019-mb. high pressure center over northern Greenland, much larger wind gradients than normal resulted across the Labrador Sea, almost equal to the January magnitudes. As spring is the time of change and unsettled conditions, so was the mean pressure chart of April as shown in figure 28f. With highs and lows interchanged, a large positive anomoly was created north of 45°N along the Newfoundland and Labrador coasts. For the first time in many years a large negative gradient (winds from the southeast) was predominent.

The Icelandic Low was undefined as frequently occurs in May (figure 28g.), with both the Azores-Bermuda and Greenland Highs slightly higher than normal. A resulting positive anomoly over the Labrador coast identified continued southeasterly winds, although of a lesser magnitude than the previous month. In figure 28h. the mean pressure pattern in the North Atlantic in June was shifted northward and eastward. The Icelandic Low was over Iceland (more than 1000 miles northeast of its average position on the coast of Labrador) and 4 mb. less than normal. Slightly above normal pressure gradients resulted along the Labrador coast.

The mean pressure pattern for July 1973 (figure 28i.) was as close to its normal as meteorlogically possible. The Bermuda-Azores High was 4 mb. higher than normal but the isobars were almost perpendicular to the Labrador coast indicating southwesterly winds and no further southerly iceberg drift wind component. Winds were from the west-southwest over the Grand Banks providing little southward movement to the remaining icebergs and enabling Ice Patrol to close out the season by the end of the month. The pressure chart for August as shown in figure 28j. is included for continuity. The pressure pattern was near normal, but with the Icelandic Low of 1005 mb. and a 1017 mb. high centered over Greenland, the isobars are much closer providing for a much greater than normal southerly flow along the Labrador coast. The previous month's warmer temperatures took their toll on the iceberg population, however, in that only one additional iceberg drifted south of 48°N.

Northwesterly winds have a profound effect on icebergs and their drift. These winds create a southerly component of wind induced iceberg drift, accentuate the volume transport (and velocity) of the Labrador Current, reduce the air and sea surface temperatures, and spreads and develops sea ice to the south and east of Newfoundland. To determine and assign numerical values to the existing wind conditions, surface pressure gradients (differences in atmospheric pressure along a geographically orientated line) may be used. Six such gradients are labeled in figure 29. Gradients 1 and 2 measure the winds off the coast of Labrador which are important in setting up the drift for transporting icebergs to the general area northeast of Newfoundland. Gradient 3 measures the component which assists or impedes icebergs as they drift along the eastern slope of the Grand Banks. Gradient 4 is a measure of the influence of the generally westerly winds along the northern slopes of the Grand Banks. This is important in drifting the icebergs away from the northeast Newfoundland coast and into the Labrador Current. If, however, they are too strong (or persistent) when the bergs reach the northeast corner of the Grand Banks, they may be carried eastward out of the Labrador Current and into warmer waters which drift generally northeastward. Gradients 5 and 6 provide a pre-season indication of potential iceberg drift south and across Davis Strait, respectively.

Figure 30. shows Gradients 5 and 6 for both the 1972 (not analyzed last year) and 1973 pre-season periods of September to February and continued through April. It is more than apparent that from the end of November and continuing until the middle of April, 1972 more than twice the average wind gradient provided southerly drift for icebergs from far to the north of Davis Strait. These northern icebergs, previously uncounted in the January pre-season survey, were given an impedous to reach the Grand Banks, a journey not possible under normal environmental conditions. This five month anomaly also extended the iceberg season to the longest on record by providing a constant flow of icebergs out of Baffin Bay.

Now looking at the 1973 season statistics on the same figure, only two months of excessive positive deviation are noted, preceeded by over a month's negative (southerly winds) gradient. Thus icebergs north of Davis Strait were subjected to normal or above drift rates after the January pre-season flights. Pressure gradient 6, although less negative than normal, indicates that the iceberg transport across Davis Strait must also be taken into account.

Referring now to the graphical representation of figure 31, Gradients 1 and 2 are extremely above normal from the first of December through the first of April. Thus the icebergs previously refered to from north of Davis Strait continued their southward drift at excessive rates. Near average gradients in the late spring and early summer months provide for continued iceberg movement south to the vicinity of 48°N, but not at the rate of the previous year. Coupling these with Gradients 3 and 4 as shown, provides for another very long season, equalling the previous year's in length, but falling short of its magnitude.

As expected from the exceptionally strong northwesterly winds, air temperatures along the Baffin Island, Labrador and Newfoundland coasts were exceptionally low beginning in December which accumulated excessive frost degree days as shown in figure 32. A frost degree day is defined as one day at a temperature one Fahrenheit degree below 32° (e.g., one day at 25°F would be seven frost degree days). Similarly, a melting degree day is one day at a temperature of one Fahrenheit degree above 32°. The rapid accumulation of melting degree days along the Labrador Coast (Hopedale and Cartwright) correlate with the southerly winds as evidenced by negative gradients (1 and 2, refered to in the previous paragraph) during April and May. Newfoundland melting degree days finally reached a normal accumulation coinciding with the end of the 1973 Ice Season.

RESEARCH AND DEVELOPMENT, 1973

During the 1973 Ice Season a final evaluation of the AN/DPD-2 Side-Looking Airborne Radar (SLAR), provided by the U.S. Coast Guard Research and Development Center, Groton, CT., was conducted. SLAR appears to be the only all-weather iceberg detection device available for the Ice Patrol, however a production model is necessary in lieu of the research SLAR that was tested due to operational considerations, i.e., repair parts readily available, real-time film processing, etc. A valuable report entitled "Iceberg Classification Using Side Looking Airborne Radar" by L. D. FARMER was published last year from the 1970 and 1971 data gathered during ice reconnaissance flights. The information contained therein remains unchanged to date and is available from the National Technical Information Service, Springfield, VA. 22151 (Order Number AD 742653). Commander, International Ice Patrol will continue efforts to obtain an operational Side-Looking Airborne Radar to significantly improve iceberg detection and identification capabilities.

Also during the 1973 season a newly developed air-deployable surface current probe was tested for its usefulness in determining iceberg drift. Due to various failures in the camera and current probes, as well as the inability to relocate icebergs and identify the dye patches, proper evaluation was not possible. However, some valuable observations and recommended improvements for future experiments were obtained. The Technical Report (Project 736411 of the Coast Guard Research and Development Center) "Iceberg Drift from Surface Currents" by Dr. J. P. WELSH, Jr. and Lieutenant S. M. PHILLIPS, USCG is included in this Bulletin as Appendix B.

ICE AND SEA SURFACE TEMPERATURE REPORTS
RECEIVED FROM SHIPS OF PARTICIPATING NATIONS
DURING 1973

	ICE	SST
BELGIUM		
LOVERVAL	3	4
CANADA		
CCGS BAFFIN	1	
CCGS d'IBERVILLE	1	
CCGS HUDSON	1	
CCGS JOHN A. MACDONALD	2	
CCGS LOUIS S. ST. LAURENT	3	
CSS DAWSON	1	
HMCS IROQUOIS	1	
IMPERIAL QUEBEC	1	
PORTE ST. LOUIS	1	
SIR HUMPHREY GILBERT	1	
DENMARK		
ESTRID	1	
LEINSTER BAY	1	2
PACIFIC SKOU	1	1
RITVA DAN	17	12
SAIMA DAN	1	2
SONJA	1	
FINLAND		
FINNFOREST	1	
KEPPO	1	
SOLANO	1	
FRANCE		
AMPERE	6	9
ANDROMEDE	1	
ATLANTIC COGNAC	1	1
ATLANTICA MARSEILLE	1	
CATHERINE	1	1
CETRA LYRA	1	1
CHARLES LD		1
COMMANDANT BOURDAIS	1	1
CYROS	1	
FRANCOIS LD	2	
LOIRE	10	9
MONT LOUIS	5	
ONDINE	1	
PENERF	1	
PENHIR	2	

	ICE	SST
FEDERAL REPUBLIC OF GERMANY		
AEGIR	1	
ALMUT BORNHOFEN	1	
ALSTER EXPRESS	4	
ANNA WESCH	1	
ANTJE SCHULTE	1	1
ATLANTIC CINDERELLA	2	
BOCKENHEIM	7	3
BUCHENSTEIN	1	
BUNTENSTEIN	1	
BUNTENTOR	1	
CAROLA REITH	1	1
CONSTANTIA	2	
EDE FOLDENFJORD	2	
ELBE EXPRESS	5	
GRETHE REITH	1	1
GRIESHEIM	1	
HAMBURGER DAMM	1	
HAMBURGER WALL	1	
HAVELLAND	1	
HEINRICH SCHULTE	2	
HERMAN SCHULTE	1	
JOSELIN	2	
MAIN EXPRESS	1	1
MARITA LEONHARDT	2	
MATTHIAS REHDER	1	
MOSEL EXPRESS	4	
MUNCHEN	4	
NORDWELLE		2
OLDENDORF	3	
POLAR ECUADOR		2
POLARLIGHT	3	
RHEIN EXPRESS	3	1
SLOMAN SENIOR	2	
SUSANNE FRITZEN	1	
SUSANNE REITH	1	
TILLY RUSS	4	
TRANSAMERICA	4	15
TRANSCANADA	1	
URSULA SCHULTE	3	
WALTER HERVIG	8	
WESER	1	
GREAT BRITAIN		
ALBRIGHT EXPLORER	1	
ALBRIGHT PIONEER	2	

	ICE	SST
ASIA LINER	1	
ATLANTIC CAUSEWAY	2	
ATLANTIC CONVEYOR	2	2
AVONFIELD	1	
BAMBURGH CASTLE	1	
BEL-HUDSON	1	1
BISNES	1	
BOSTON YORK	1	
CAPE FRANKLIN	1	
CAPE HOWE	8	1
CAPE NELSON	1	
CP AMBASSADOR	3	
C.P. DISCOVERER	7	
C.P. EXPLORER	16	
C.P. TRADER	6	
C.P. VOYAGEUR	11	1
CHEVIOT	1	
CHILTERN PRINCE	1	
COUNTY CLARE	2	
DALHANNA	3	
DART AMERICA	7	2
DART ATLANTIC	1	
DROXFORD	2	
DUKESGARTH	1	
DUNKYLE	1	
EDENMORE		9
EXPLORER	2	
FINNISH WASA	1	4
FORTUNA	2	
GLENPARK	1	
HARFLEET	1	
HECTOR	1	
HELEN MILLER	1	
HILLA		11
IDA LUNDRIGAN	1	1
INISHOWEN HEAD	8	
KING ALFRED	1	
LA PAMPA	1	
LAURENTIAN FOREST	5	
LOTTINGE	1	
LUNDRIGAN	1	1
MANCHESTER CASCADE	1	
MANCHESTER CHALLENGE	2	
MANCHESTER CONCEPT	3	
MANCHESTER CONCORDE	7	1
MANCHESTER COURAGE	7	
MANCHESTER CRUSADE	4	
MANCHESTER QUEST	5	
MANCHESTER VIGOUR	6	

	ICE	SST
MANISTEE	1	
MONKSGARTH	1	
NEWFOUNDLAND	2	
QUEEN ELIZABETH II	2	
QUEENSGARTH	9	
RIO COBRE	1	1
ROSEWOOD	1	
ST. MARGARET	9	10
SALTNES		4
SANTONA	5	
SEASTAR	1	
SILVERDON	1	
SUSAN CONSTANT	1	3
SUSAN MILLER	1	
VANCOUVER TRADER	2	
WELSH HERALD	1	
CALL SIGN - GOOH	1	

GREECE

	ICE	SST
ADELFLOTIS	2	
AEGIS FAITH	1	1
AGIOS NICOLAOS IV	1	
ARISTEIDES	1	
ASHBURN	1	
BUENA FORTUNA		1
CAPETAN KOSTIS	1	
ERATO	1	
ERON	1	
EURYGENES	1	
FEDERAL SEAWAY	1	
FILIA	1	
ICAROS	1	
ITHAKI ISLAND	1	
KOUTOURIARIS	1	
LCKOMEDIS	1	1
LEONIS HALCOWSSIS	1	1
MARYLISA	2	3
MICHALAKIS	1	1
MICHALISK	1	
PERICLES HALCOUSSIS	2	
REA		1
REGALSON	1	

ISRAEL

	ICE	SST
ZIM HAIFA	1	

ITALY

	ICE	SST
ADRIANA AUGUSTA	1	
ANNA BIBOLINI	1	

	ICE	SST
BENEDETTA F	1	
GOLFO DI PALERMO	2	
LENONARDO DA VINCI		14
MICHELANGELO		7
POLINNIA	1	
PORTORIA		2
VELA	1	

JAPAN

	ICE	SST
JAPAN MAGNOLIA	3	
KANETOSHI MARU		2
TANSEI MARU		1
TOKEI MARU	1	
ZENKOREN MARU NO.2		1

LIBERIA

	ICE	SST
AEGEAN SKY	4	
ARGO LEADER	1	
CALEDONIA	1	
CAPE PALMAS	2	
COSMOPOLITAN	1	
EASTERN GLORY	1	
ERMIS		1
GOLDEN JASSON	1	
GRISCHUNA		5
IIKONTAK	1	
MARATHONIAN	1	
MAREDALE	1	
MAST COURIER	3	
MELTEMI	3	1
MOZART	1	
NAVITRADER	1	1
NEW FRONTIERS	4	
NICOLAS MARIS	1	
OGDEN EXPORTER	1	4
OSWEGO PLANTER	1	
REGINA OLDENDORFF		2
SACHA		2
ST. ATHINA	1	
STOLT ATLANTIC		2
STOLT NORNESS		2
THARROS	1	
TRENTWOOD	2	1
VOLTA PEACE	1	

NETHERLANDS

	ICE	SST
ADRIATIC	1	
HNLMS ISAACS WEERS		1
HNLMS TIJGER HAAI		1
MEERDRECHT	2	
MOORDRECHT	5	
POLEDYK	1	
SCHOUWEN	1	1
SOLENDREAT	1	
TUBAL	2	

NORWAY

	ICE	SST
ANINA	1	1
BELLAMI	1	1
CLARO	2	
DAGRUN	1	1
DYVI OCEANIC	1	
DYVI PACIFIC	2	
EK	4	
FERNFIELD	2	
FOLDENFJORD	1	
FOSSUM	1	
GAUSDAL		2
HAPPY DRAGON		2
HARDANGER	2	
HAVJARL	1	
LEIKVIN	1	
RANENFJORD	1	6
RUDOLF OLSEN	1	
SAGAFJORD	3	2
TANABATA		1
TOPDALSFJORD	1	
VISTAFJORD	1	
WESTBULK	1	
WILFRED	1	

PANAMA

	ICE	SST
ASIA FIDELITY	1	
AURALIS	2	2
ESSO SCRANTON	4	
MARDINA COOLER	1	
SEE GERMANY	3	

SPAIN

	ICE	SST
CASTILLO MANZANARES	1	
LUCHANA	1	1
RIVADEMAR	2	

SWEDEN

	ICE	SST
ARVIDSJAUR	3	
ATLANTIC SONG	1	
ATLANTIC SPAN	12	57
ATLANTIDE	7	
FINLAND	1	
GRIPSHOLM	1	
MONTMORENCY	2	
SCANDIC WASA	1	18

UNITED STATES OF AMERICA	ICE	SST
AMERICAN ALLIANCE		1
AMERICAN COURIER	1	
AMERICAN LEADER	1	
EXPORT FREEDOM	1	
LIGHTNING	2	
SEA-LAND McLEAN	1	
TEXAS SUN	1	
U.S. COAST GUARD		
USCGC BIBB	18	
USCGC BOUTWELL	9	7
USCGC CHASE	6	
USCGC CHAUTAUQUA	7	3
USCGC DEPENDABLE	3	1
USCGC DUANE	32	
USCGC EDISTO	1	
USCGC ESCANABA	6	
USCGC EVERGREEN	33	
USCGC HAMILTON	18	2
USCGC INGHAM	1	
USCGC MORGENTHAU	10	
USCGC MUNRO	4	
USCGC OWASCO	22	7
USCGC PONTCHARTRAIN	6	5
USCGC RED BEECH	1	1
USCGC SHERMAN	13	13
USCGC SOUTHWIND	2	1
USCGC SPENCER	2	1
USCGC TANEY	1	1
U.S. NAVY		
USS INTREPID	1	
USNS MAUMEE	1	
USNS MIRFAK	1	
USNS PVT. JOHN R. TOWLE	4	
USNS SCHULKILL	2	1

YUGOSLAVIA	ICE	SST
BANIJA	2	11
BOSANKA	1	8
IVO VOJNOVIC	1	14
KOPER	4	5
KRAS	2	
KRPAN	1	
PIRAN	3	6
SISAK	1	

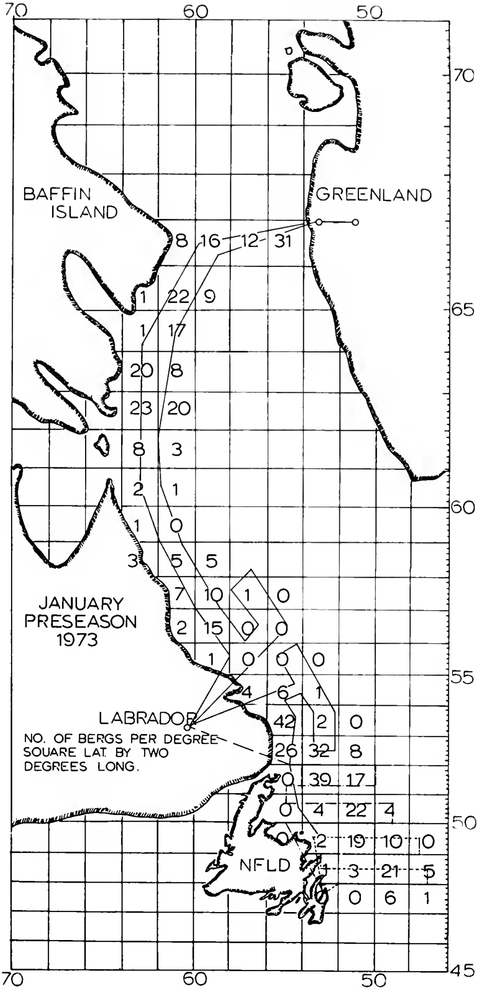

FIGURE 1.—Pre-season Iceberg Survey 9–19 January 1973.

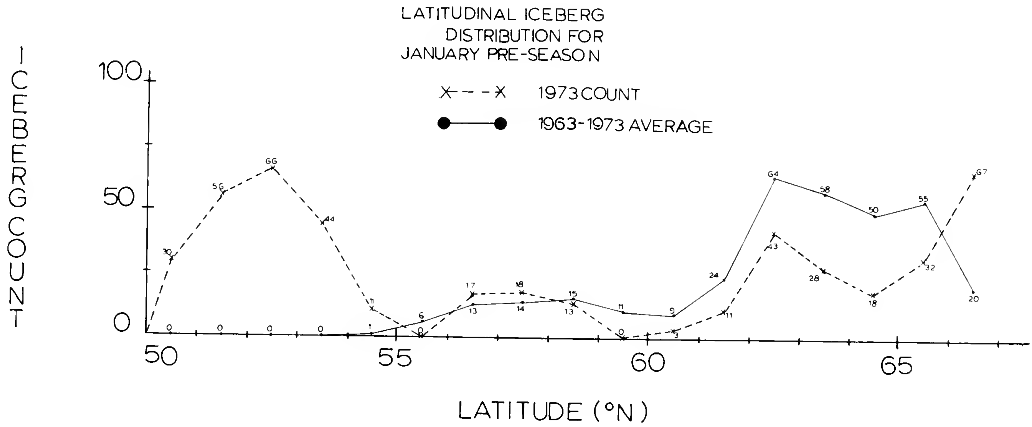

FIGURE 2.—Latitudinal Iceberg Distribution, January Preseason Flights.

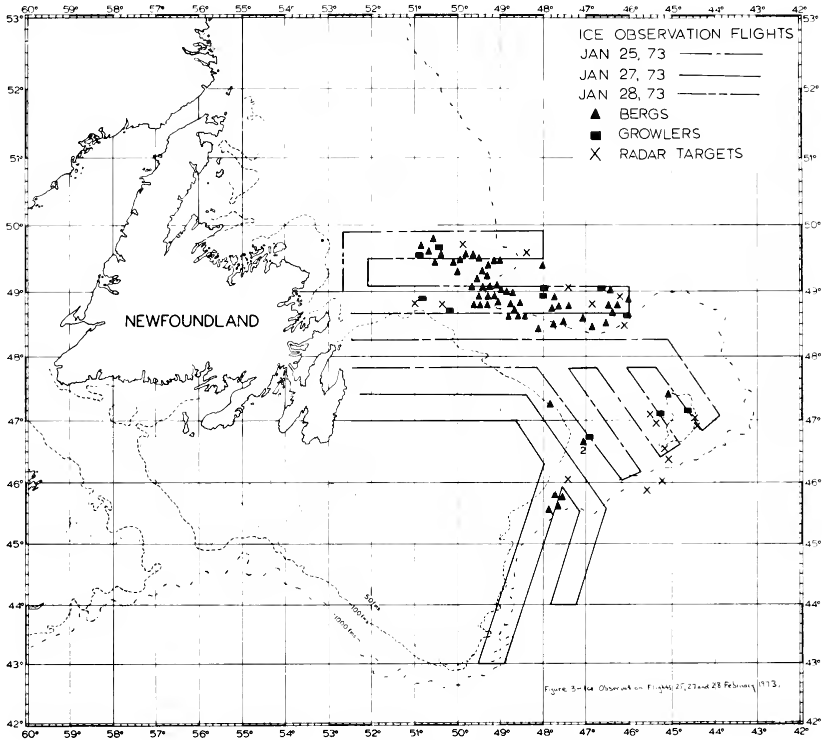

FIGURE 3.—Ice Observation Flights 25, 27, and 28 February 1973.

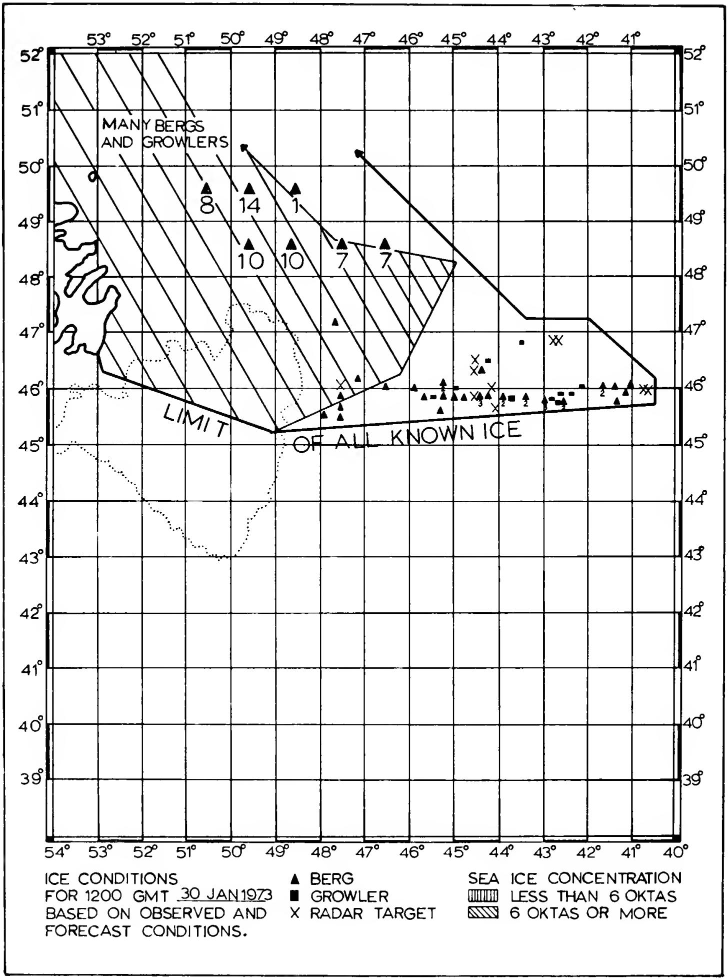

FIGURE 4.—Ice Conditions, 1200 GMT 30 January 1973.

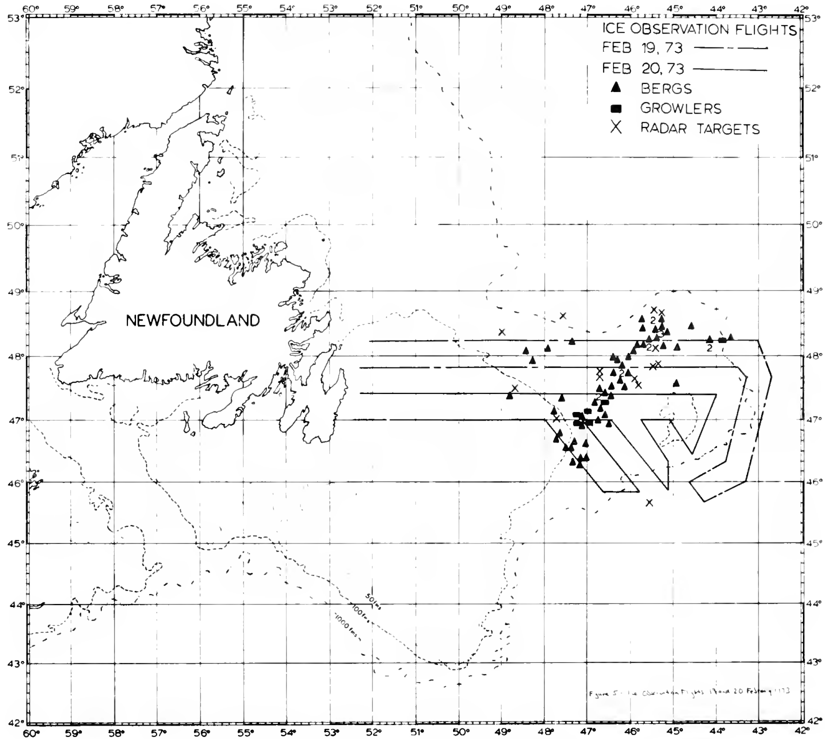

FIGURE 5.—Ice Observation Flights 19 and 20 February 1973.

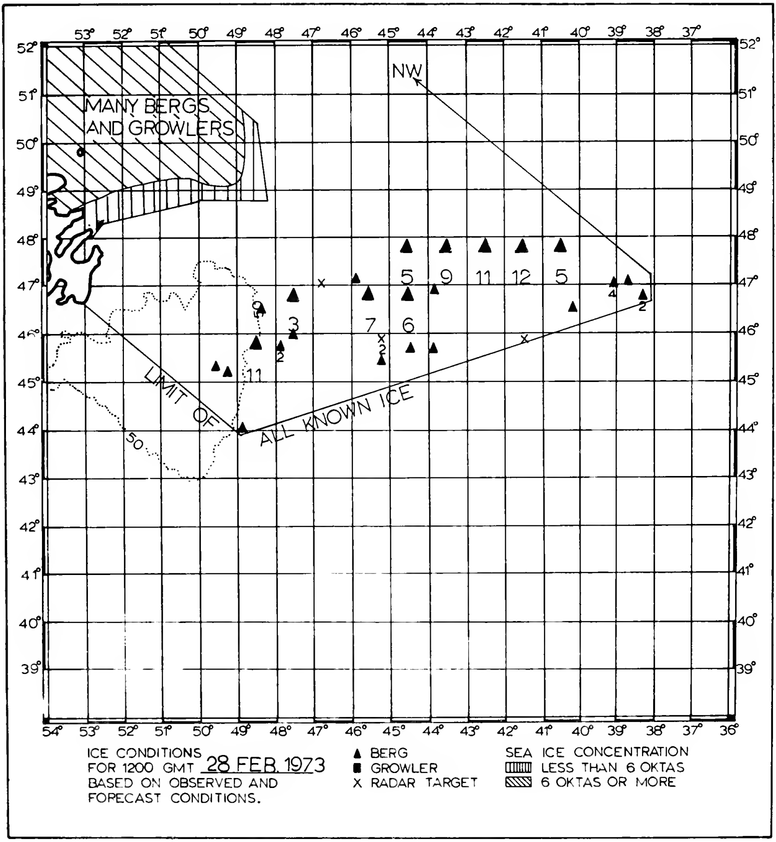

FIGURE 6.—Ice Conditions, 1200 GMT 28 February 1973.

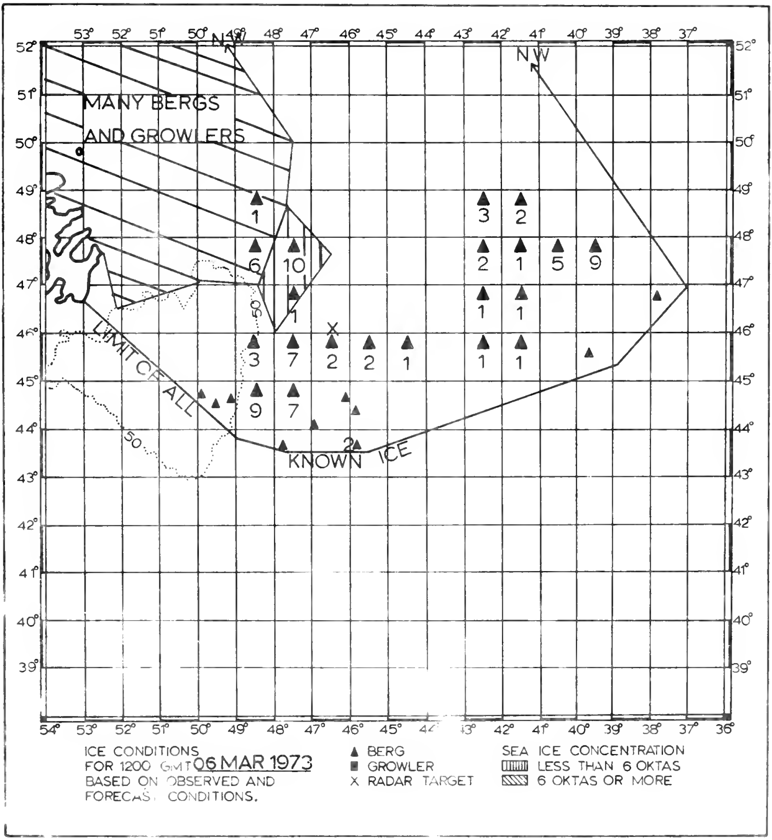

FIGURE 7.—Ice Conditions, 1200 GMT 6 March 1973.

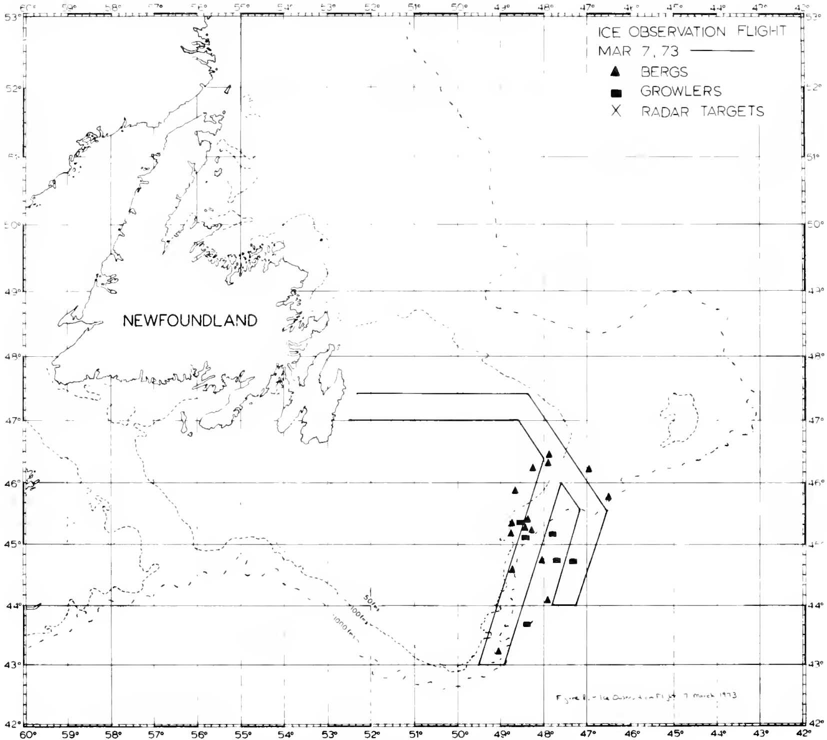

FIGURE 8.—Ice Observation Flight 7 March 1973.

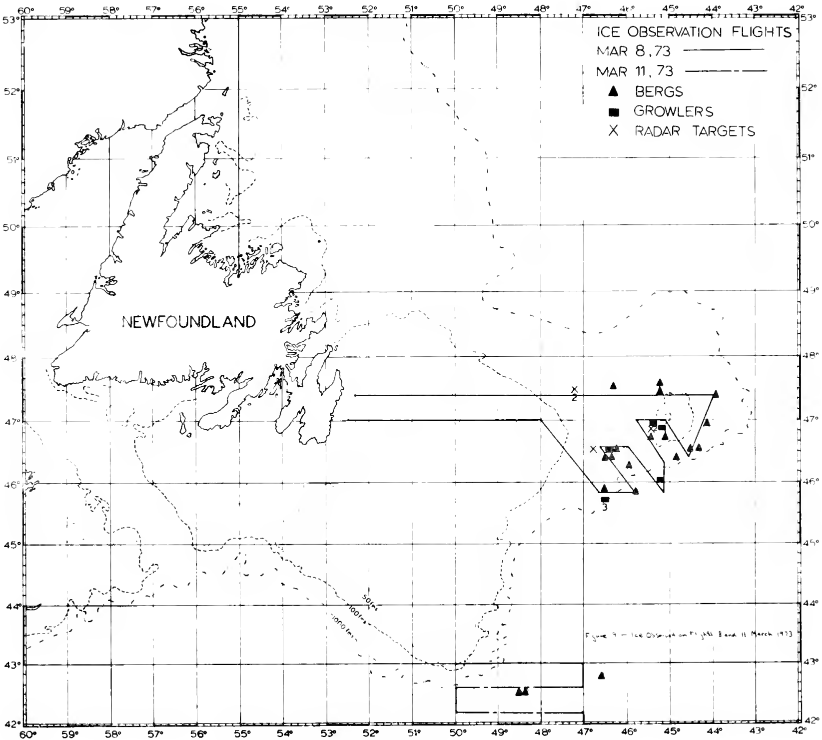

FIGURE 9.—Ice Observation Flights 8 and 11 March 1973.

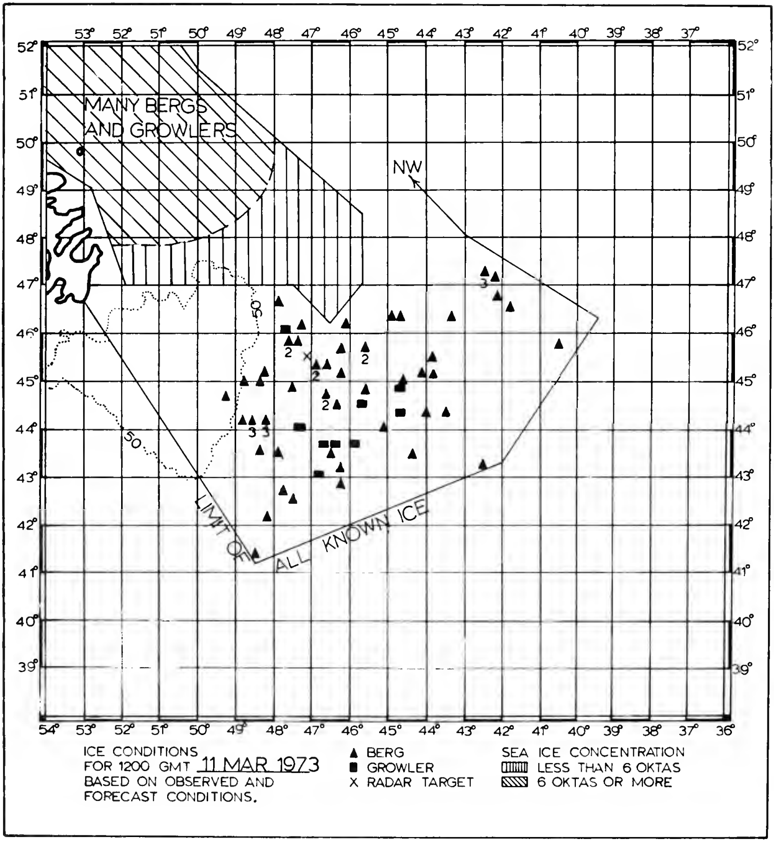

FIGURE 10.—Ice Conditions, 1200 GMT 11 March 1973.

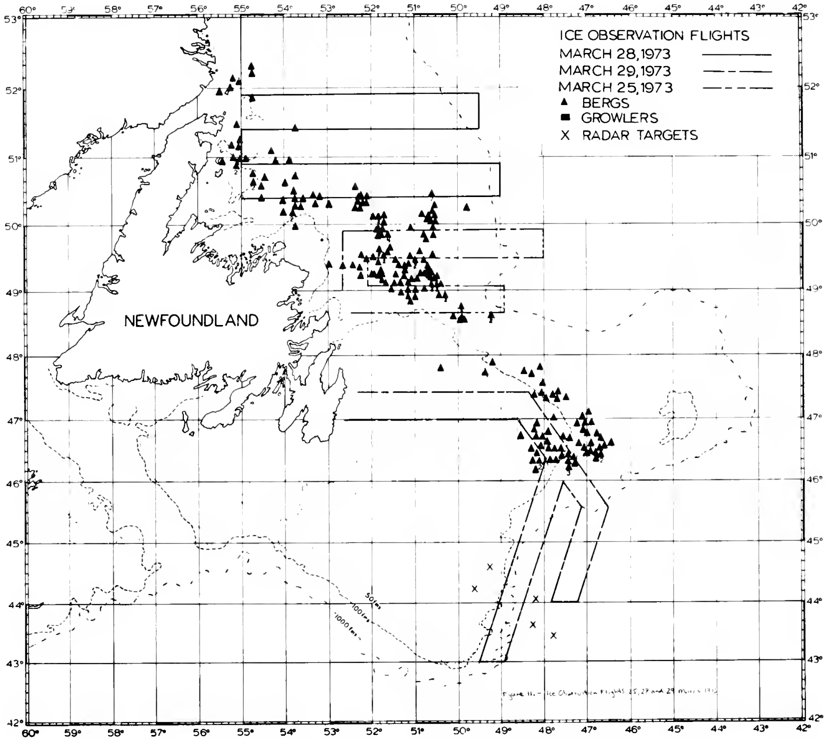

FIGURE 11.—Ice Observation Flights 25, 28, and 29 March 1973.

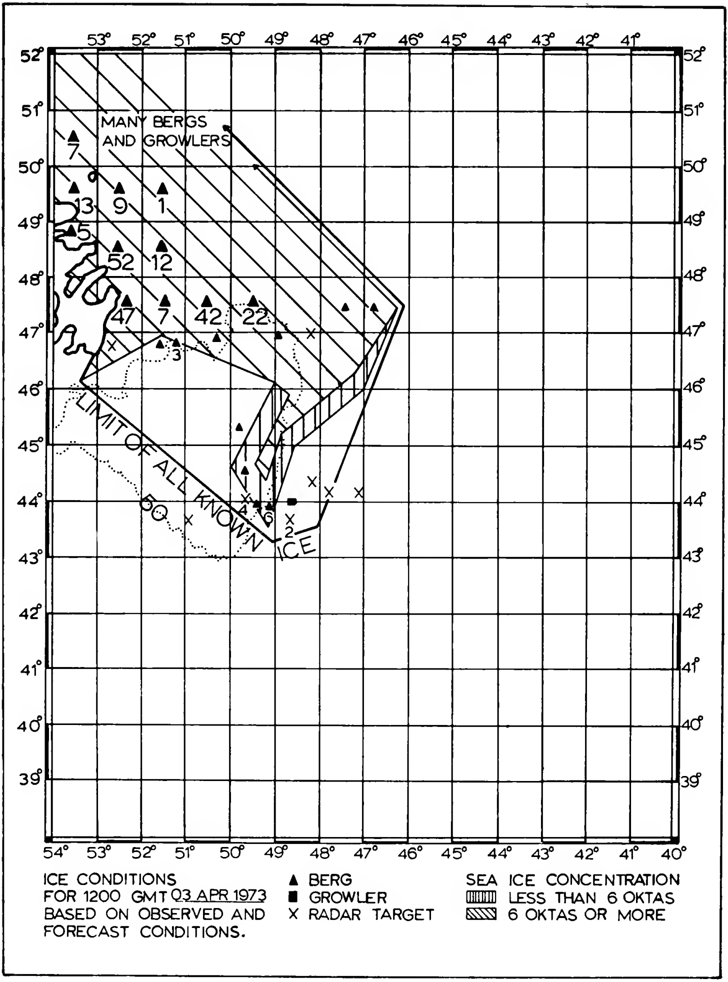

FIGURE 12.—Ice Conditions, 1200 GMT 3 April 1973.

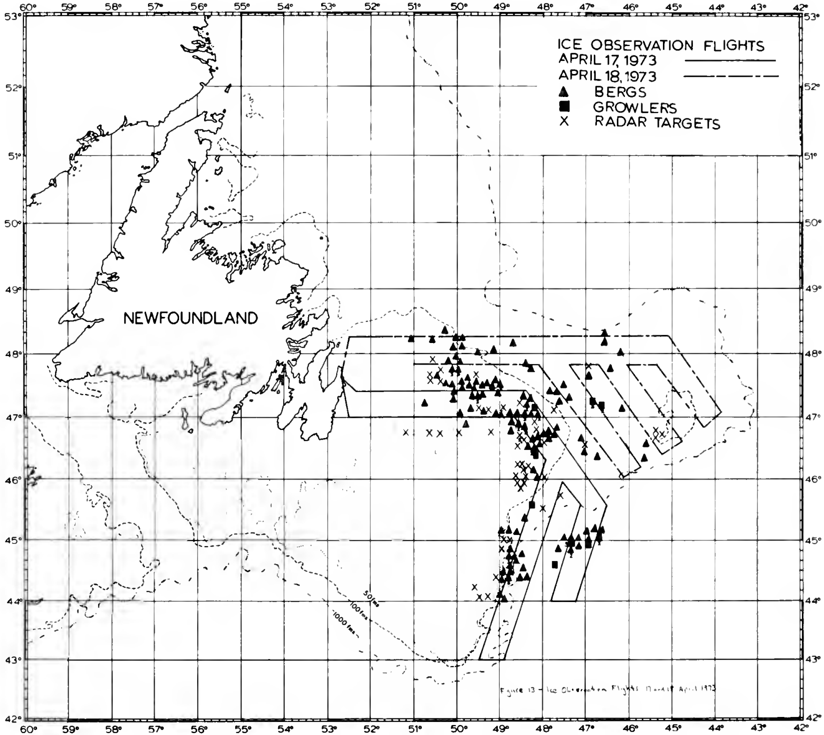

Figure 13.—Ice Observation Flights 17 and 18 April 1973.

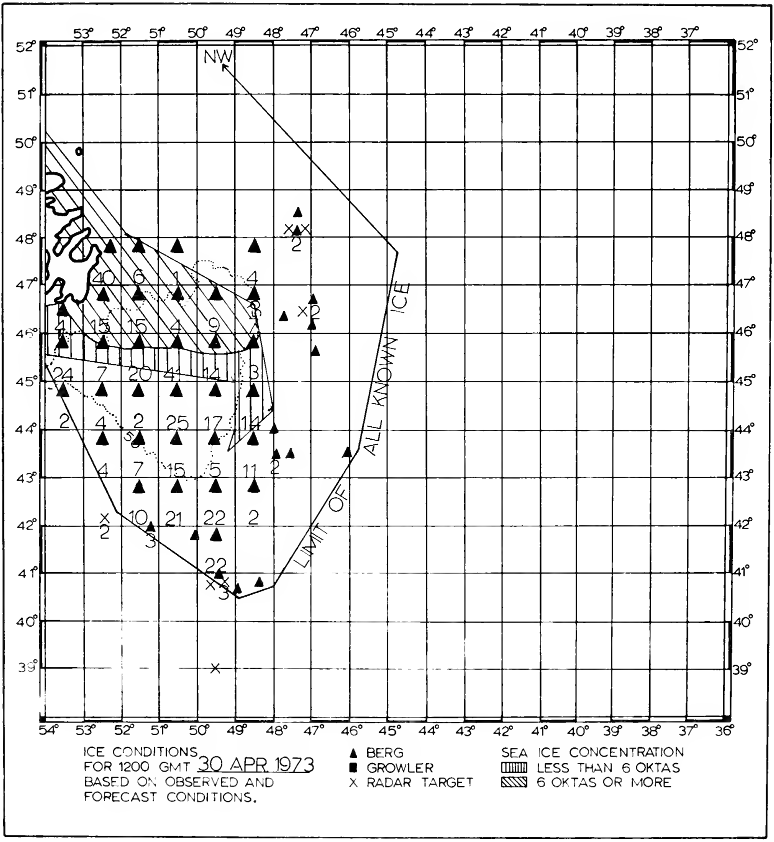

Figure 14.—Ice Conditions, 1200 GMT 30 April 1973.

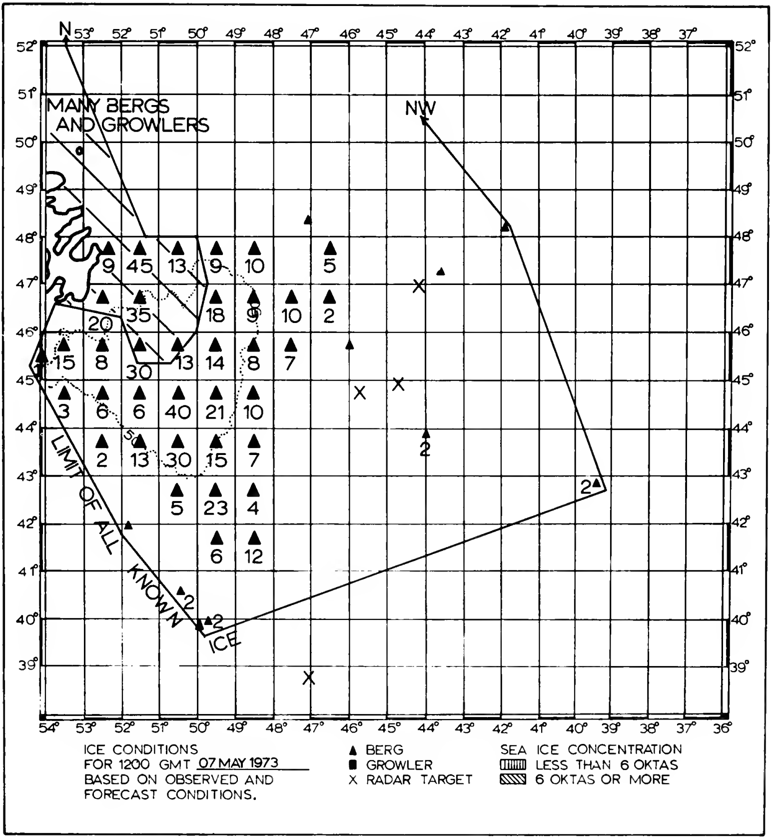

FIGURE 15.—Ice Conditions, 1200 GMT 7 May 1973.

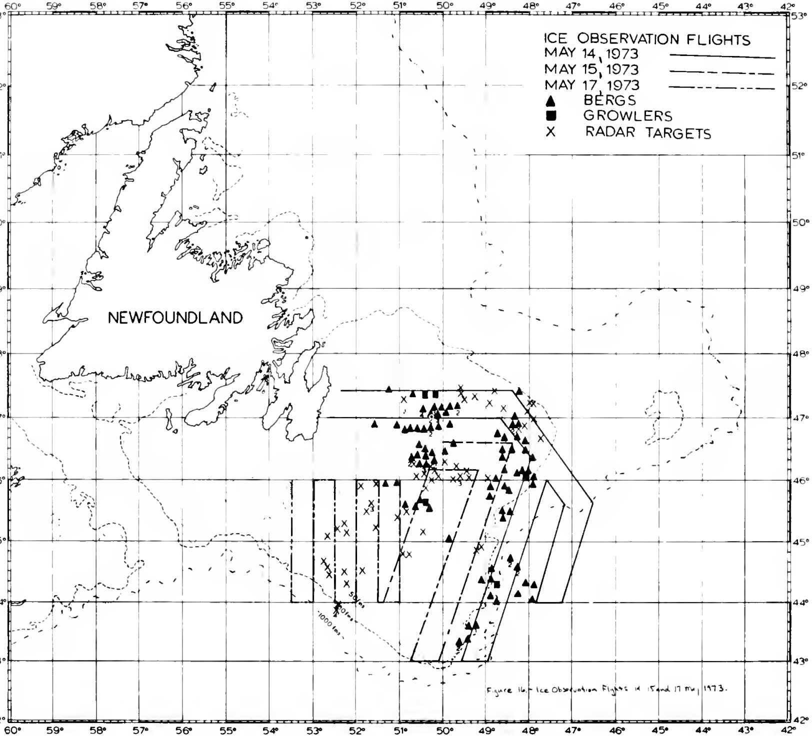

FIGURE 16.—Ice Observation Flights 14, 15 and 17 May 1973.

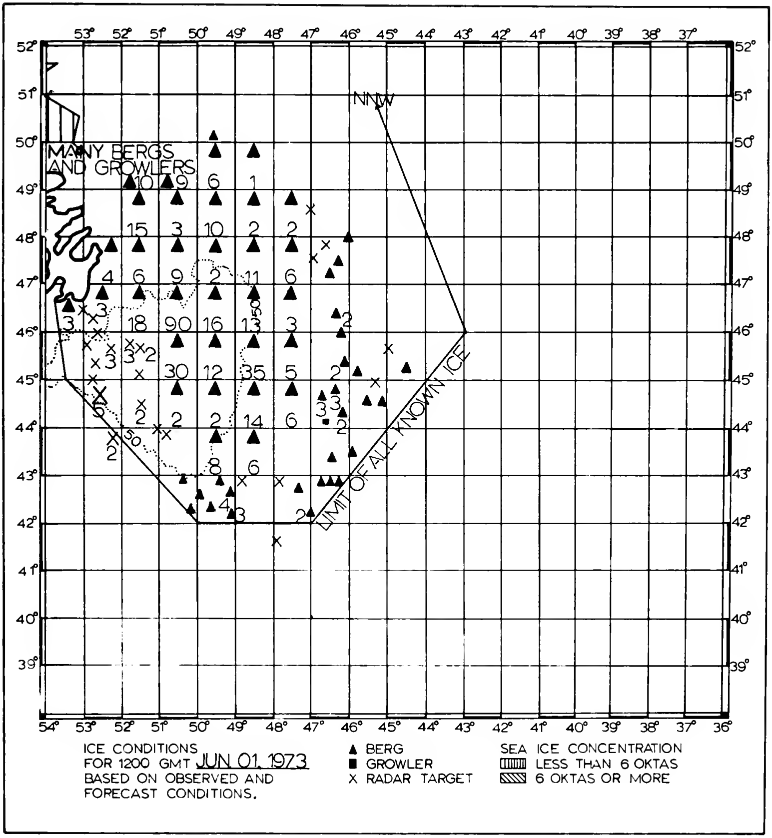

Figure 17.—Ice Conditions, 1200 GMT 1 June 1973.

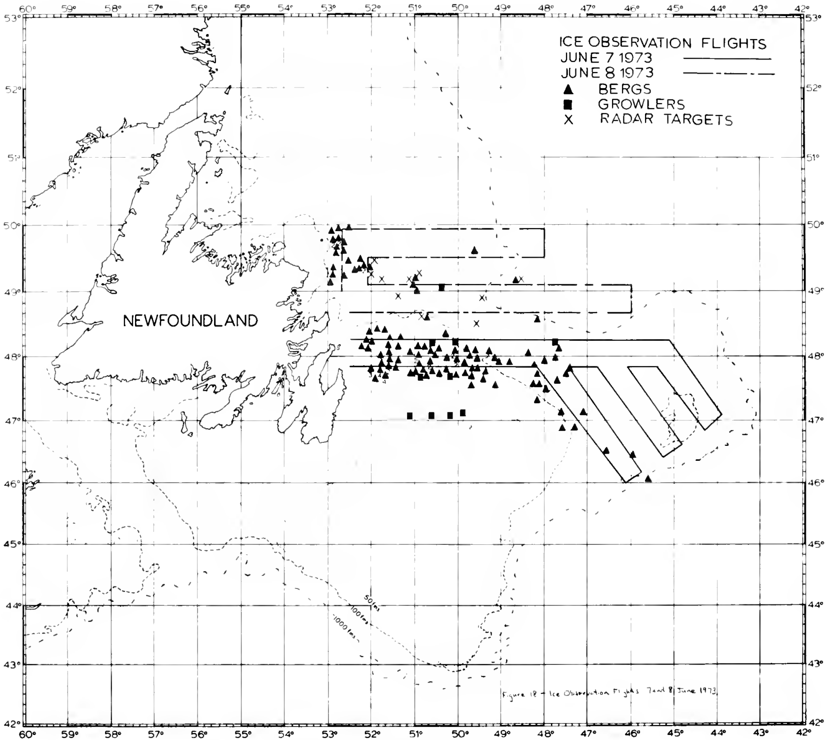

FIGURE 18.—Ice Observation Flights 7 and 8 June 1973.

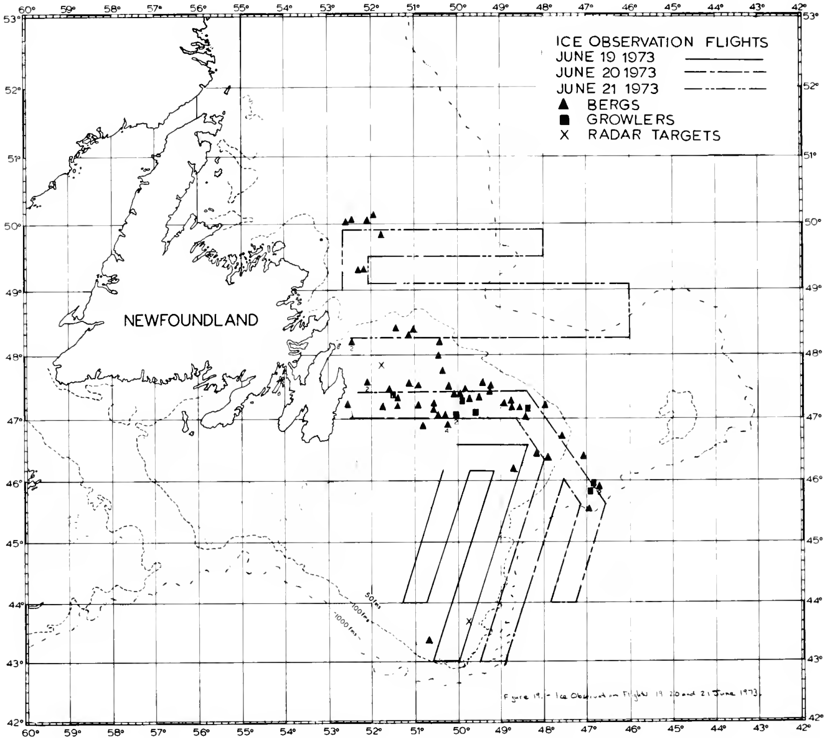

FIGURE 19.—Ice Observation Flights 19, 20, and 21 June 1973.

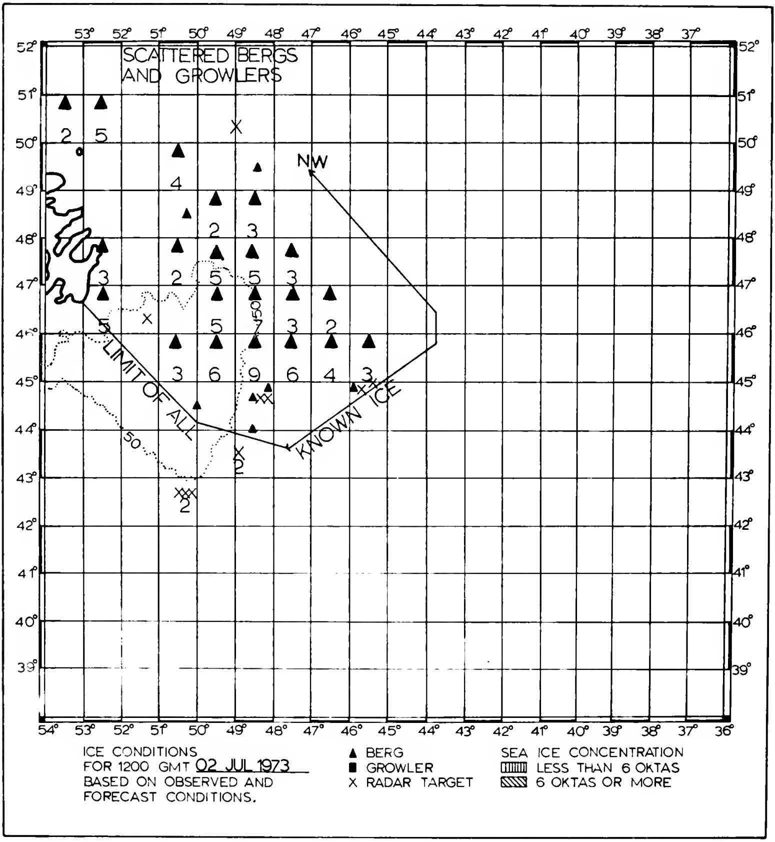

FIGURE 20.—Ice Conditions, 1200 GMT 2 July 1973.

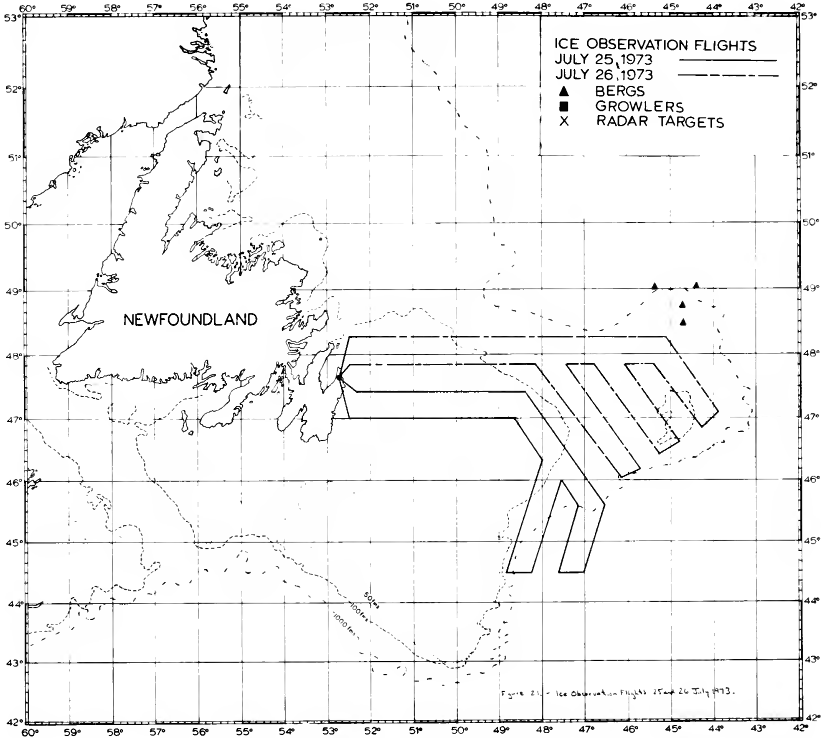

Figure 21.—Ice Observation Flights 25 and 26 July 1973.

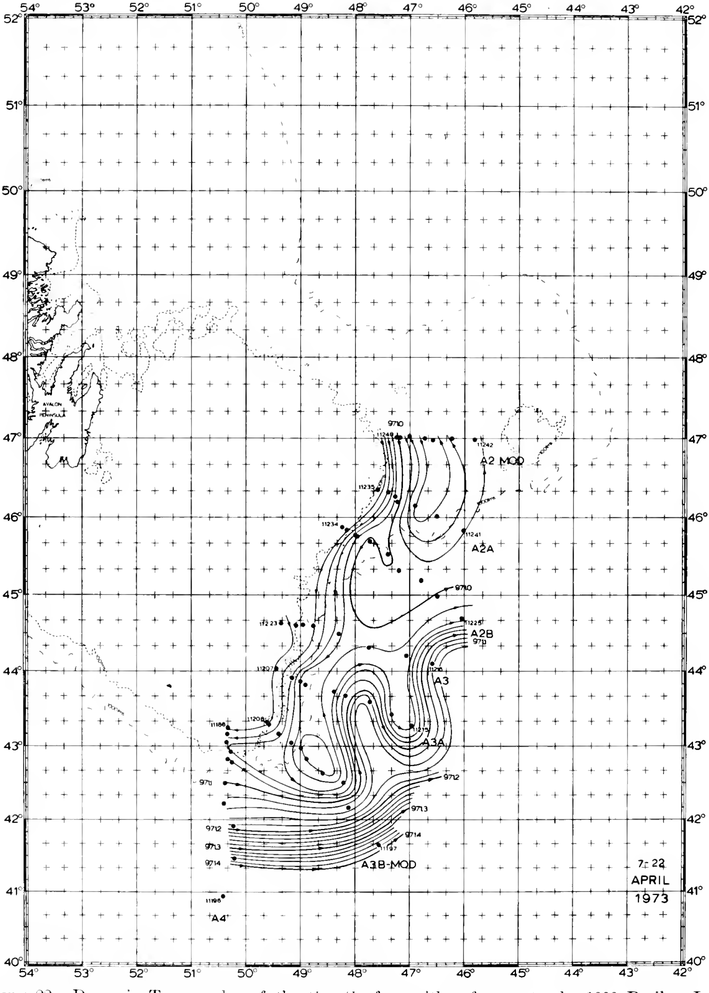

FIGURE 22.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. First Cruise, April 1973.

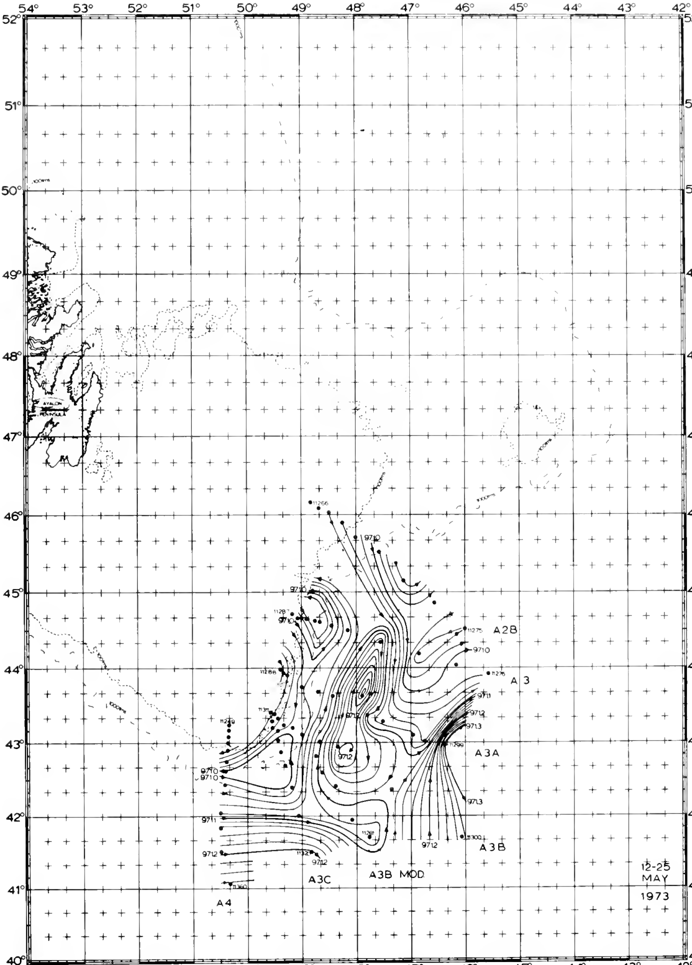

FIGURE 23.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. Second Cruise, May 1973.

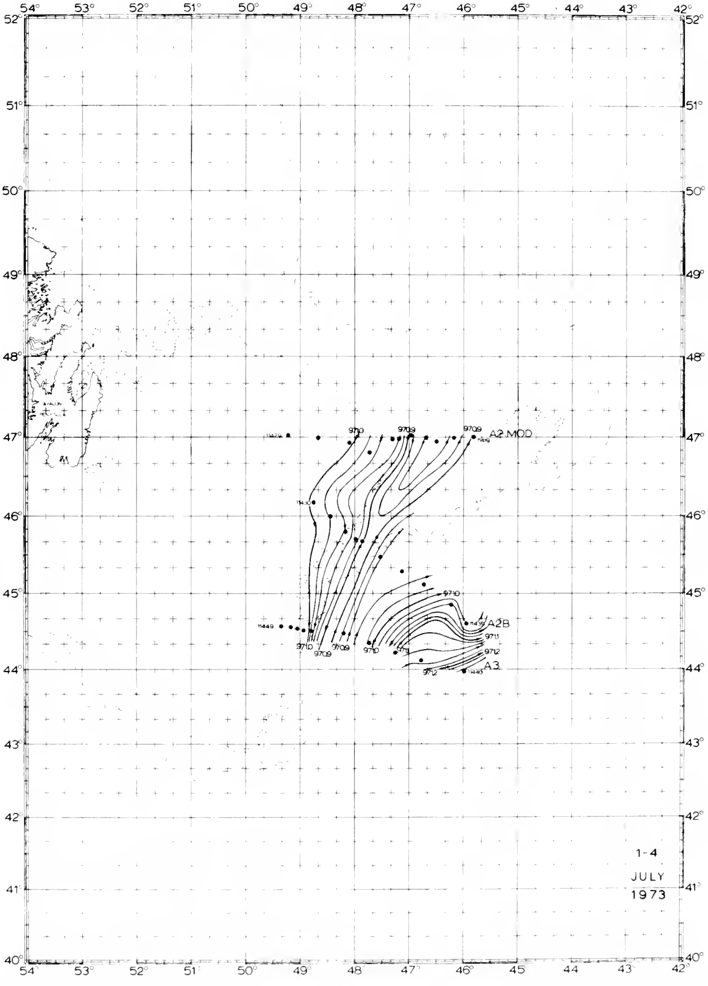

FIGURE 24.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. Third Cruise, July 1973.

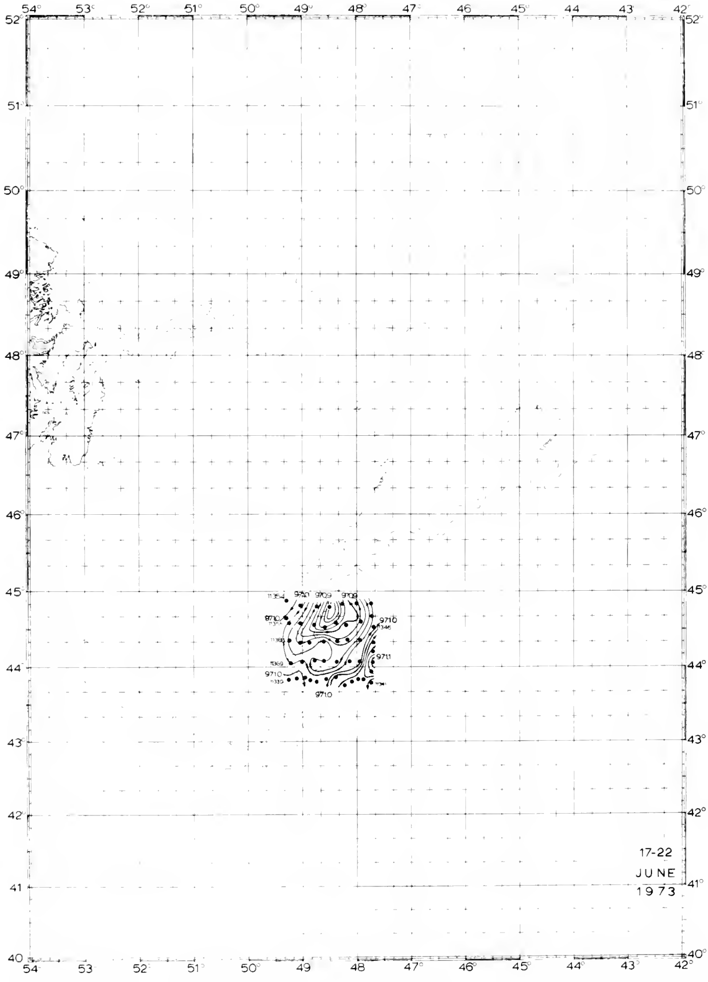

FIGURE 25.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. First Special Survey, 17–22 June 1973.

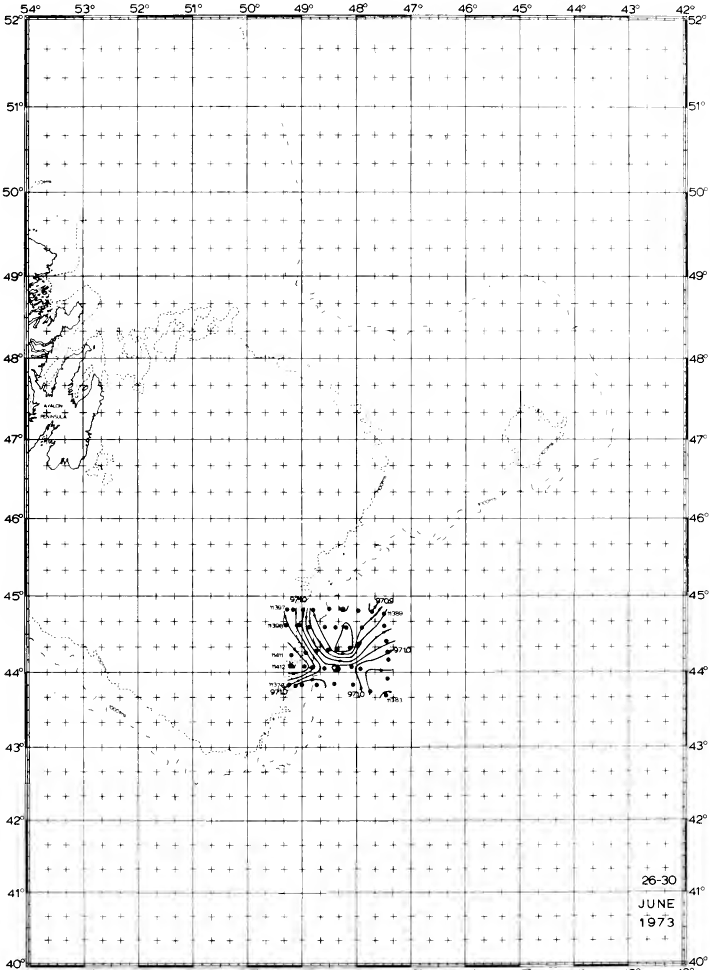

Figure 26.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. Second Special Survey 26–30 June 1973.

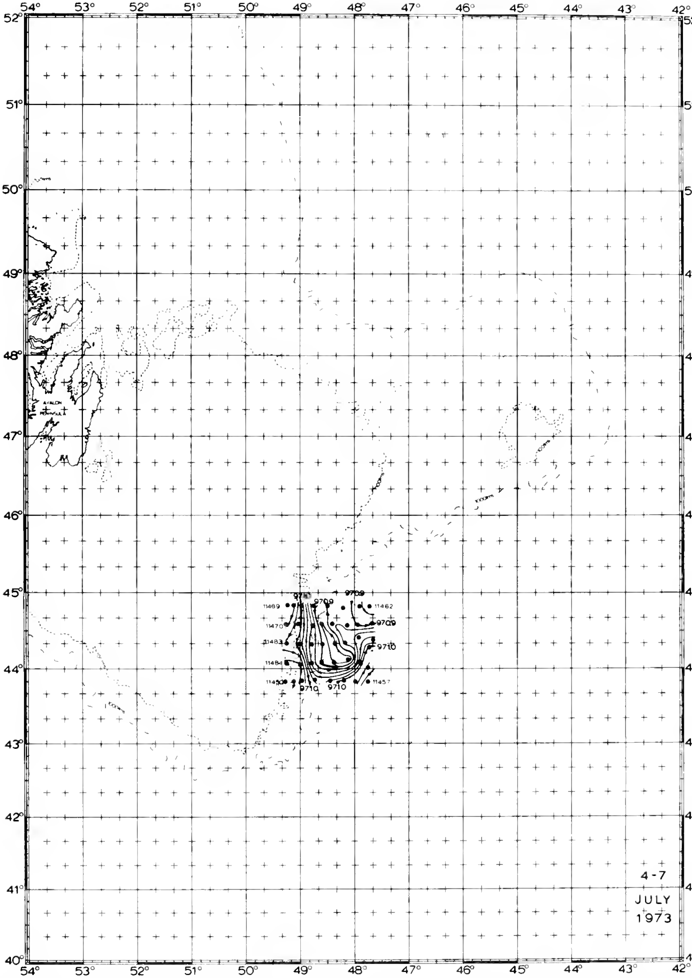

FIGURE 27.—Dynamic Topography of the Sea Surface with reference to the 1000 Decibar Level. Third Special Survey, 4–7 July 1973.

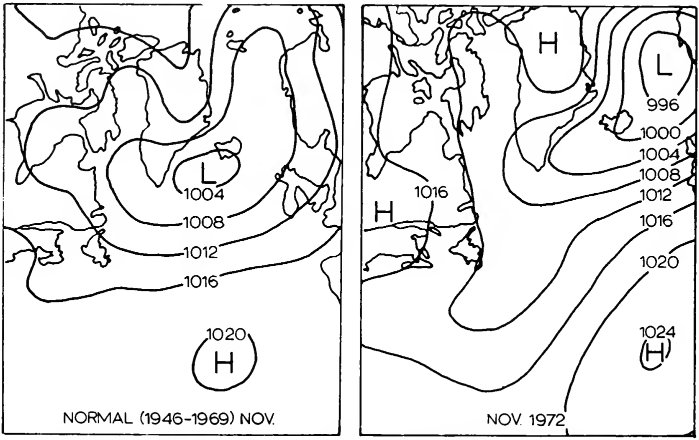

Figure 28a.—November Normal and 1972 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

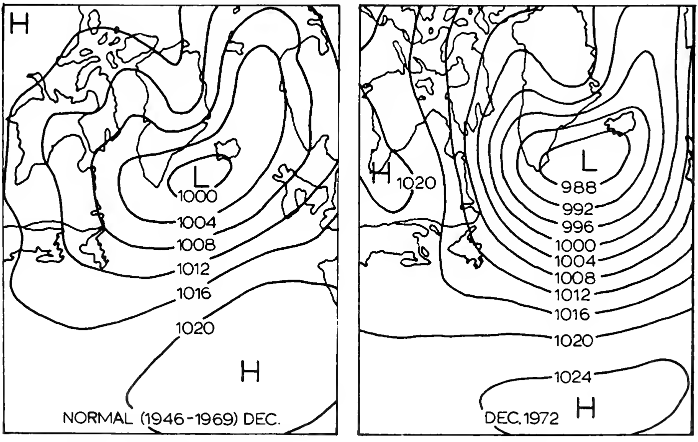

Figure 28b.—December Normal and 1972 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

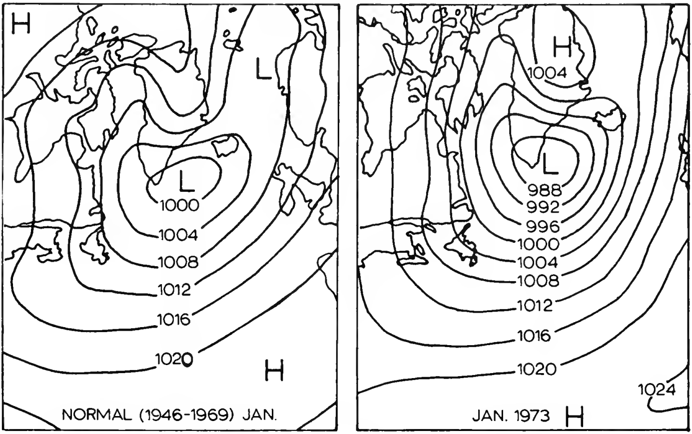

FIGURE 28c.—January Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

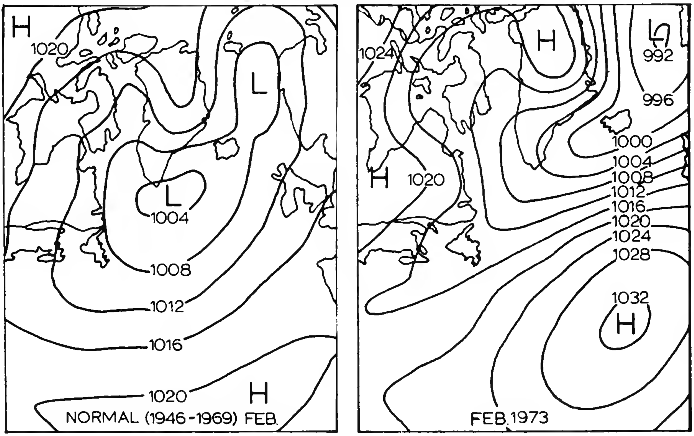

FIGURE 28d.—February Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

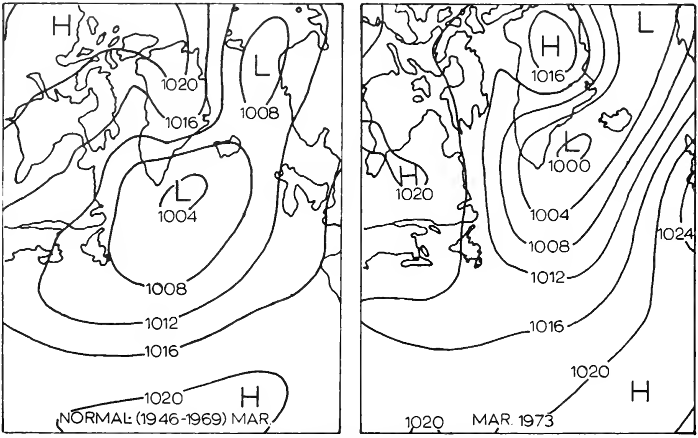

FIGURE 28e.—March Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

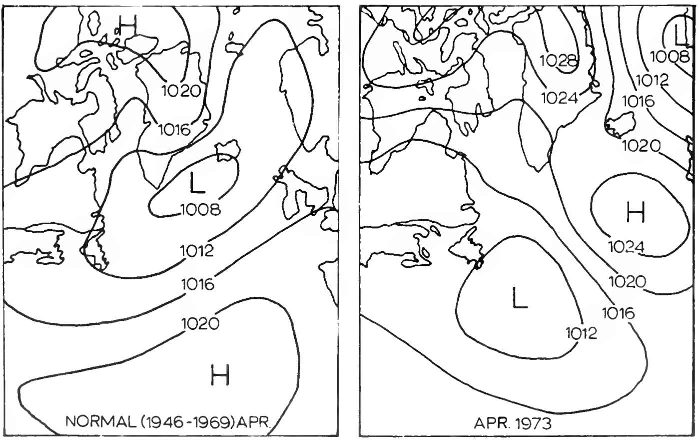

FIGURE 28f.—April Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

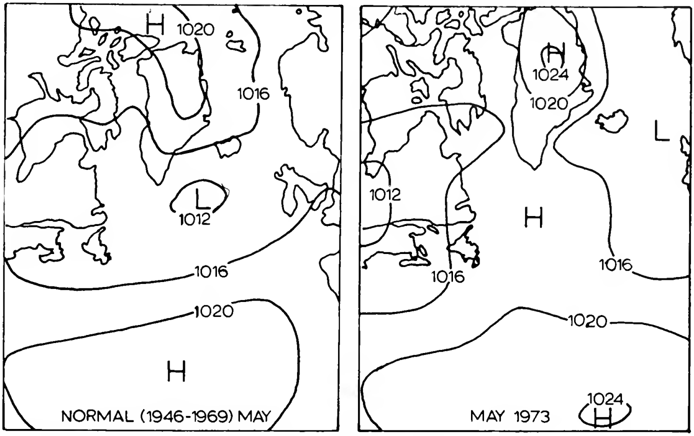

Figure 28g.—May Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

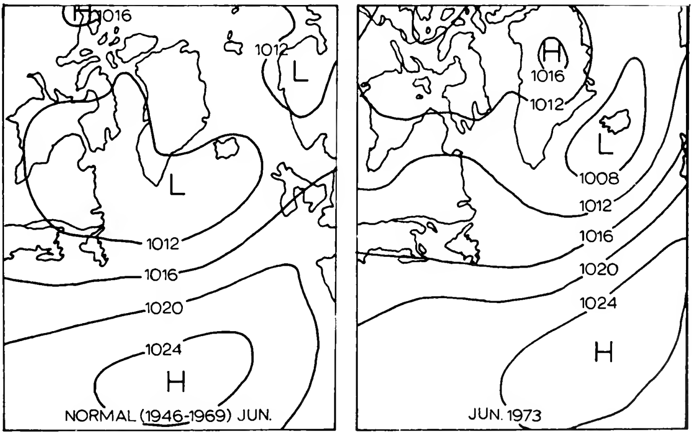

Figure 28h.—June Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

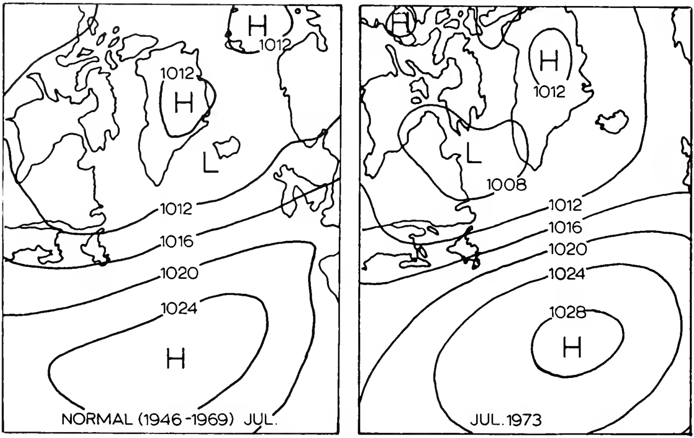

Figure 28i.—July Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

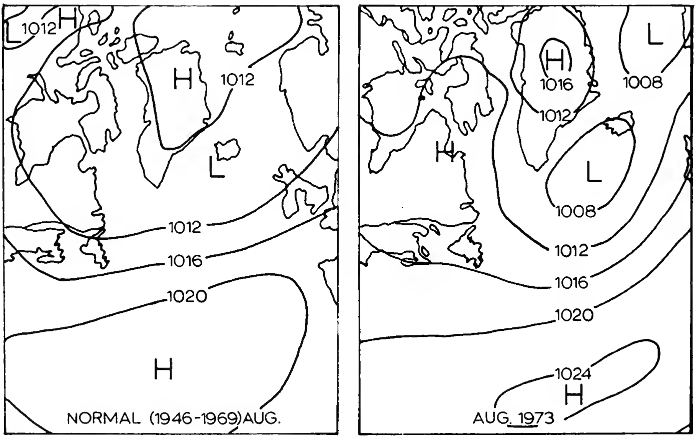

Figure 28j.—August Normal and 1973 Monthly Average Surface Pressure in mbs Relative to 1000 mbs.

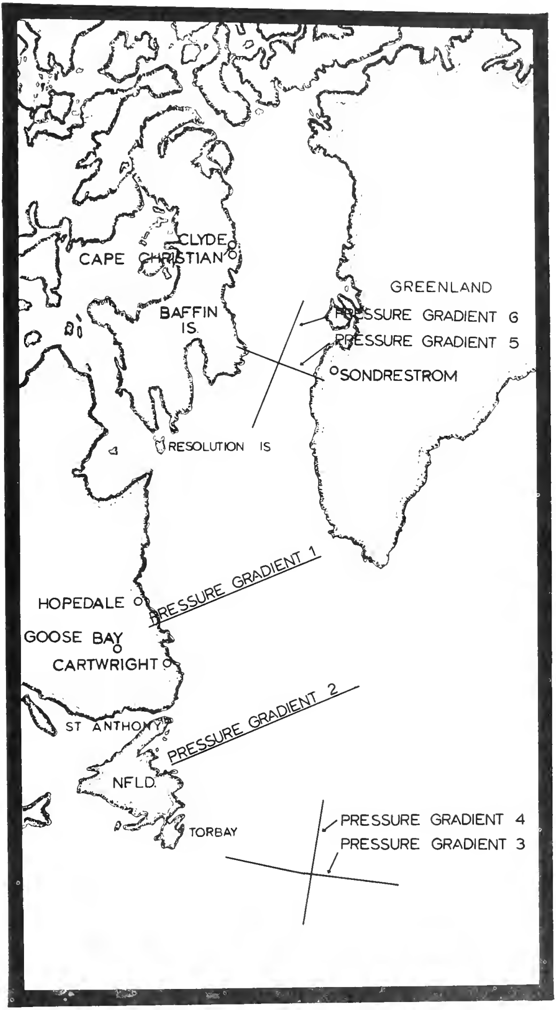

FIGURE 29.—Pressure Gradients Monitored by International Ice Patrol.

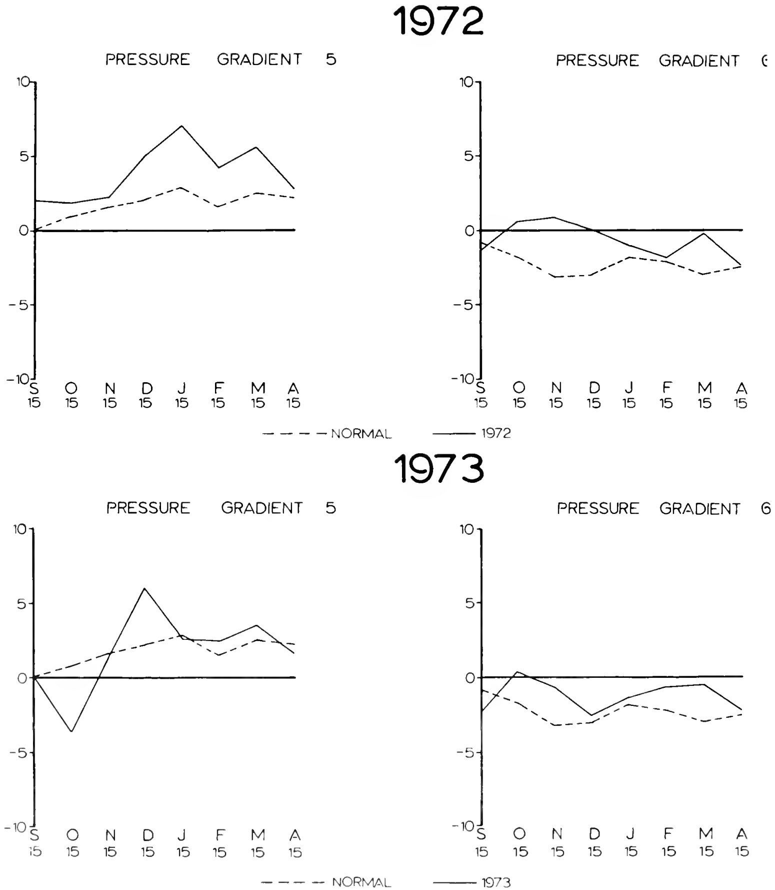

FIGURE 30.—Pressure Gradients 5 and 6.

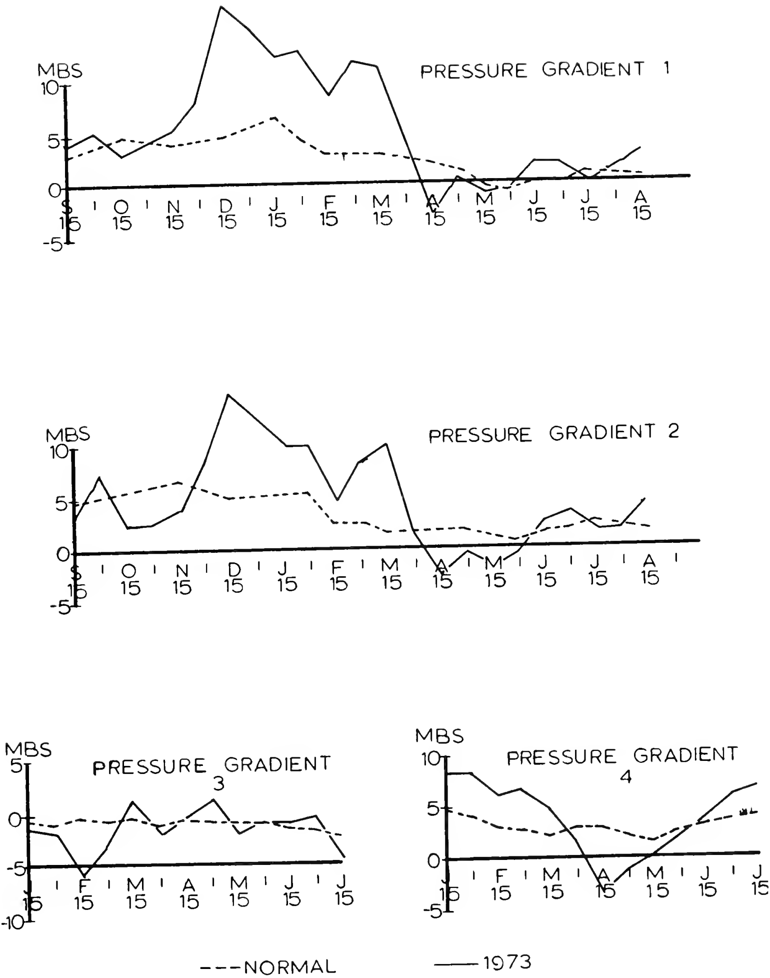

FIGURE 31.—Pressure Gradients 1–4.

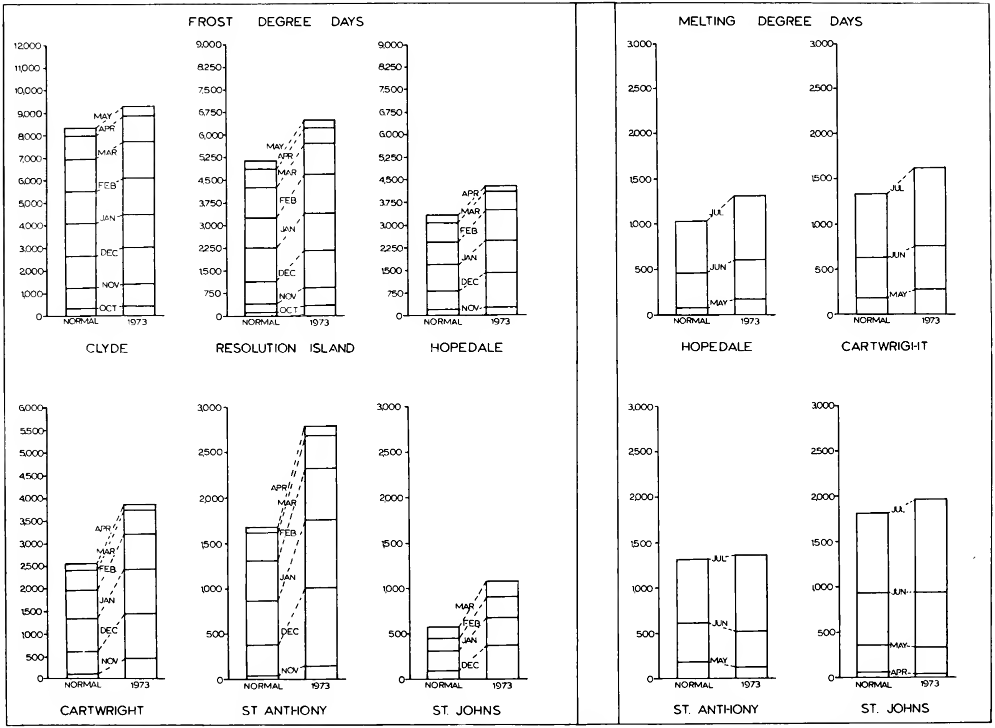

Figure 32.—Frost Degree Day and Melt Degree Day Accumulations Calculated from Monthly Mean Fahrenheit Air Temperatures.

APPENDIX A
ICEBERG CASUALTIES

Over 61 years have elapsed since the tragic sinking of the RMS TITANIC, the international clamor from which brought about the International Ice Patrol. In conducting an extensive literature search for other iceberg related casualties, letters, newspaper accounts and the files of Lloyds have been reviewed. These results are tabulated on the following pages to present the reader an awesome display of the death and destruction brought upon mankind by one of natures formidable creations.... the iceberg.

Neither the 19 incidents in the hundred years before nor the 37 incidents in the 61 years after the TITANIC are meant to be all inclusive. There have been undoubtedly many instances of "brushing" against icebergs with damage so minor as to not require reporting as well as occasions of iceberg damage that were never reported. There are also ships which have left port on trans-Atlantic voyages and been claimed by the ocean without report. Some of these are undoubtedly attributable to icebergs. Readers with information on iceberg casualties not included on this list or amplifying data on the categories labeled as unknown are invited to send them to Commander, International Ice Patrol, Building 110, U.S. Coast Guard Support Center, Governors Island, NY 10004.

Because of the above, a reasonable statistical analysis of the data is not possible. It is interesting to note, however, that in over half the reported incidents the ships either sank or were abandoned. What is important, is the fact that not one reported iceberg casuality has occurred in the vicinity of the Grand Banks of Newfoundland outside the eastern, south-eastern and southern limits of all known ice as published by the International Ice Patrol. In the column "GRAND BANKS AREA?" a YES indicates the casualty occurred within the limits of all known ice; a NO indicates that the casualty occurred in a different geographical location.

TABLE OF ICE INCIDENTS

DATE	POSITION	GRAND BANKS AREA?	DESCRIPTION OF INCIDENT	LIVES LOST/ INJURIES	DAMAGE
1818-1838	UNK	UNK	Packet WILLIAM BROWN hit iceberg, 16 survivors were thrown from lifeboat	UNK	Ship sank.
January 29, 1856	UNK	UNK	Wood Paddle Steam Ship PACIFIC hit iceberg	186 lives lost	Ship sank.
January 30, 1856	5 days out of Liverpool	YES	Iron Paddle Steam Ship PERSIA hit iceberg at 11 knots.	UNK	16ft of bow flatten.
February,1856	UNK	YES	Iron Paddle Steam Ship PERSIA hit growler and sea ice	UNK	Tore away paddle wheel legs and sponson.
January 29 or 30, 1870	Left Halifax January 28	YES	SS CITY OF BOSTON hit ice-berg	177 lives lost	Ship Sank.
January 1880	Grand Banks	YES	SS ARIZONA hit iceberg	None	Minor Damage.
June 2, 1882	20 miles south of Cape Race	YES	SS ASHDRUBAL hit iceberg	UNK	Ship Sank.
January 2, 1884	46-00N 46-20W	YES	SS NOTTING HILL hit iceberg	None	Ship Aban-oned.
May 7, 1885	Grand Banks	YES	SS ANNIE CHISTINE hit ice-berg	UNK	Ship Sank.
July 18, 1893	Grand Banks	YES	Wood Barque MARTHA hit iceberg	UNK	Ship Con-demned.
April 25, 1894	North Atlantic	YES	Wood Barque RUTH PALMER hit iceberg	UNK	Ship Sank.
May 18, 1896	Off Cape Race	YES	Wood Barque ALICE M. CLARIDGE hit iceberg	UNK	Ship Sank.
1896	160 miles off Cape Race	YES	Wood Barque VALBORG	UNK	Ship Aban-oned.
August 19, 1896	North Atlantic	YES	SS MOLDAVA hit iceberg	UNK	Ship Sank.
April 17, 1905	Grand Banks	YES	Wood Schooner SAINT GEORGES hit iceberg	UNK	UNK
April 24, 1906	North Atlantic	YES	SS ANGELO PERUVIAN hit ice-berg	UNK	Ship Sank.
July 26, 1906	Strait of Belle Isle	NO	Wood Schooner STELLA B. WOOD hit iceberg	UNK	Ship Sank.
1908	North Atlantic	YES	Wood Barque COLOMBA LOFARD hit iceberg	UNK	Ship Con-demned.

DATE	POSITION	GRAND BANKS AREA?	DESCRIPTION OF INCIDENT	LIVES LOST/ INJURIES	DAMAGE
April 11, 1912	10mi from TITANIC sinking	YES	SS NIAGARA (saw 500 foot iceberg)	UNK	Holed by ice-berg.
April 14, 1912	4146N 5014W	YES	RMS TITANIC hit iceberg	1513 lives lost	Ship Sank.
1913	Grand Banks	YES	SS MOUNT TEMPLE hit iceberg	UNK	UNK
May 1914	East of Cape Race	YES	SS ROYAL EDWARD hit iceberg	None	Exten-sive damage to bow.
May 29, 1914	4529N 4820W	YES	Wood Schooner GOLFINHO hit iceberg	UNK	Ship Sank.
May 25, 1919	4713N 5122W	YES	SS CASSANDRA hit iceberg	None	Forward Compart-ments flooded.
January 28, 1922	Voyage Liverpool to Newscastle N.S.W. Australia	UNK	SS GARTHFORCE hit iceberg	UNK	Damaged sold as hulk.
April 24, 1923	4857N 4755W	YES	SS LE RAYMOUND hit iceberg	None	Ship Sank.
April 25, 1923	4615N 4405W	YES	SS ET BRETAGNE hit iceberg	None	Ship Sank.
June 23, 1925	Tail of the Grand Banks	YES	SS SAUGUS hit iceberg	None	Ship Sank.
May 1928	Northern Grand Banks	YES	SS MONTROSE hit iceberg	2 lives lost	Exten-sive damage to fore-castle.
July 20, 1929	Tail of the Grand Banks	YES	SS VIMEIRA hit iceberg	None	Exten-sive damage to bow plates and propel-ler.
May 17, 1933	Off Cape St. Francis	YES	SS SEIRSTAD hit iceberg	UNK	Ship Sank.
October 11, 1933	Labrador Sea	NO	Wood Schooner MAIA hit iceberg	UNK	Caught Fire and Sank.
April 11, 1935	Labrador Sea	NO	Wood Schooner SAINT COULOMB hit iceberg	UNK	Ship Sank.
October 1, 1935	Hudson Strait	NO	SS BRIGHT FAN hit iceberg	UNK	Ship Sank.
July 17, 1937	Strait of Belle Isle	NO	SS CAIRNGLEN hit iceberg	None	Minor Damage.
June 9, 1939	150 miles east of St. John's, New-founded	YES	Wood Schooner BEN-HUR hit iceberg	UNK	Caught Fire and Aban-doned.

DATE	POSITION	GRAND BANKS AREA?	DESCRIPTION OF INCIDENT	LIVES LOST/ INJURIES	DAMAGE
August 7, 1939	5158N 5418W	NO	SS BEAVERHILL hit iceberg	None	Minor Damage.
January 9, 1940	Denmark Strait	NO	SS BAHIA BLANCA hit iceberg	UNK	Ship Sank two days later.
March 19, 1943	5805N 4415W	NO	SS SVEND FOYN hit iceberg	UNK	Ship Sank two days later.
June 14, 1944	Davis Strait	NO	F/V MARIA PRECIOSA hit iceberg	UNK	Ship Sank.
May 29, 1945	4308N 4918W	YES	Convoy O.N. 303 encountered an iceberg in fog. 4 ships hit iceberg, 20 ships collided with each other.	None	Slight Damage.
June 24, 1946	Grand Banks	YES	F/V COMMANDANTE TEN REIRO hit iceberg	None	Ship Sank.
June 6, 1948	4800N 5220W	YES	M/V NEVADA hit iceberg	None	$35,000 damage.
September 1952	Davis Strait	NO	F/V RIO CAIMA hit iceberg	UNK	Ship Sank.
February 4, 1957	48 miles east of Cape Breton	NO	M/V PETIT hit iceberg	UNK	Ship Sank.
January 30, 1959	5930N 4300W	NO	M/V HANS HEDTOFT hit iceberg	95 lives lost	Ship Sank.
May 24, 1959	4700N 5230W	YES	M/V LYDIA MARIA hit 20'x 100' iceberg at 9 knots	None	Extensive dry-docking required.
May 1960	Off Newfoundland	YES	M/V QUEENSGARTH hit iceberg	None	Hold Flooded.
November 25, 1965	Off Kap Farvel, Greenland	NO	M/V BURGERMEISTER SMIDT hit iceberg	UNK	Ship Sank.
April 23, 1967	Off Newfoundland	YES	M/V BATORY hit iceberg	None	7ft hole 15 feet below waterline.
June 1968	Chance Harbor, Newfoundland	NO	Ice fell from iceberg onto small boat	1 life lost	Boat crushed.

DATE	POSITION	GRAND BANKS AREA?	DESCRIPTION OF INCIDENT	LIVES LOST/ INJURIES	DAMAGE
April 22, 1969	Near Greenland	NO	Unknown German M/V hit iceberg	None	Bow holed.
July 1970	Baffin Bay	NO	USCGC WESTWIND struck iceberg	None	Minor Damage.
April 23, 1971	5304N 5214W	NO	F/V SANTA ISABELL hit iceberg	None	UNK
August 12, 1972	40 miles east of Cape Bauld, Nfld.	YES	M/V RATTRY HEAD hit iceberg	None	Minor Damage.
February 3, 1973	Near Grand Banks 45°48'N 46°23'W	YES	M/V HAVJARL hit iceberg	None	Exten- sive Bow Damage.
May 7, 1973	Near Newfoundland coast	YES	M/V NAVI CHAMPION hit iceberg	None	Rup- tured 4 meters in fore- peak.

APPENDIX B

ICEBERG DRIFT FROM SURFACE CURRENTS

by Dr. J.P. Welsh, Jr. and LT S.M. Phillips, USCG
(U.S. Coast Guard Research and Defelopment Center)

Introduction

The operational requirements of the International Ice Patrol (IIP) are to locate icebergs that menance the North Atlantic shipping lanes off the Grand Banks of Newfoundland and to predict their movement. A computerized iceberg drift model has been developed to assist in the performance of these requirements. This model, developed from first principles and checked with observational iceberg drift data, will produce relatively precise positions when supplied with precise values of current, wind velocity, iceberg mass, drag coefficients, values for sail area, and immersed cross section area.

The objective of this iceberg drift study was to determine by field tests the usefulness of an expendable surface current probe for determination of iceberg drift as it applies to IIP needs. This recently developed air-deployable device measures surface current precisely, rapidly, and inexpensively.

The method of determining the surface current is illustrated in Figure 1. An expendable probe is launched, and on contacting the sea surface a surface marker (SM in Figure 1) separates and floats on the surface. This serves simply to mark the location of the measurement. The remainder of the probe is carried to the bottom by its weight and from its fixed location on the bottom, releases two floats (marked F1 and F2 in Figure 1) with a predetermined time delay between them. The floats return to the surface by their own buoyancy. At the surface these floats emit fluorescein dye to aid in visual location on the surface. The surface current and direction are obtained by the following relationships.

$$\text{Surface current} = \frac{\text{Separation of F1 and F2}}{\text{Time delay between float releases}}$$

$$\text{Surface current direction} = \text{direction from F2 to F1}$$

(Broida and Richardson, 1972)

It is also possible to determine volume transport per unit width if the depth of the water is known and the distance from SM to Fl is determined.

Procedures

During the 1973 iceberg season two field experiments with the expendable surface current probe were conducted. An IIP C-130 aircraft equipped with a CA14 aerial camera and inertial navigation system (INS) was made available on an opportunity-only basis. The field test procedures consisted of selecting a "young", plateau type iceberg which is not grounded and is in an area where the water depth is not greater than 1000 meters (as indicated on bathymetric chart). The position of the selected iceberg was recorded from the INS.

A figure eight flight maneuver with the iceberg at the intersection (Figure 2) served as an efficient deployment pattern. The preferred ground speed and altitude of the aircraft during deployment were 150 knots and 1000 feet respectively.

The measurement technique is based on the release of floats containing dye at predetermined time intervals. The probe containing three floats, timer, and parachute is dropped from the aircraft into the water. The first float is released on the surface. The appearance at the water surface of the remaining two floats is dependent on the actual water depth and the preset time. The aircraft time on station is directly related to the actual water depth where the drop occurs. For example, if the water depth is 500 meters, the on-station time would be not less than 25 minutes. The total time on station included deployment of four current probes as in Figure 2, the photography run, and dye marking of the iceberg. Dye marking the iceberg assists in identification of the iceberg on succeeding tests.

The primary data recorder for this experiment was the CA14 aerial camera. The flight pattern for the photography runs was similar to that of the launch pattern (as indicated in Figure 2), so that film sequencing would be in proper order for interpretation. After the launch, the oceanographer was to assist with the sighting of the floats and the completion of a Surface Current Data sheet. The Surface Current Data sheet provides the parameters to interpret and analyze the photography.

The experiment was to be repeated in exactly the same manner at a later date on the same iceberg. The subsequent location and identification of the iceberg would provide "surface truth" for the predictive technique used in this experiment.

Conclusions

Due to the failures in the data recording camera the current probe, iceberg relocation, dye patch identification, and personnel, it is not possible to properly evaluate the expendable surface current probe for determination of iceberg drift from these experiments. However, some worthwhile observations can be made.

The experiment on 14 and 15 May 1973 showed that "in flight" identification of floats was possible. The observed surface current direction and the INS-indicated iceberg drift during the experiment were approximately equal. Predictive capabilities were lost due to camera failure and the resultant inability to measure surface current velocity.

Further experimentation on 23 June with an operative camera indicated that surface currents could be accurately measured with the available equipment and procedures. The comparison of actual iceberg drift and the measured surface current could not be made due to failure to relocate the iceberg.

The data obtained from the experiments on 29 and 30 June is questionable. Failure to unambiguously identify the dye patches and properly complete the Surface Current Data sheet results in speculative interpretation of the data. This interpretation shows a large difference between the average indicated surface current of 1.6 knots, 002°T and the observed iceberg drift of 0.6 knots, 137°T. This large difference could be explained by the fact that icebergs have been observed to trail a wake, indicating movement relative to the surface current.

The observed failure rates for the five deployments were 25%, 25%, 75%, 100% and 50% respectively. The average failure rate for all deployments was 52%. Failures can be attributed to a variety of causes, including malfunction of the parachute, malfunction of the probe (presumably the clock), strong bottom currents, and the inability of personnel to differentiate among the dye patches.

Recommendations

Further experimentation is necessary to evaluate the expendable surface current probe for determination of iceberg drift. In future experiments only two probes should be deployed to determine the surface current. The probes should be at least 1/2 mile north and south or east and west of the iceberg to be clear of the iceberg wash. Deployment of two probes in such a manner would reduce the ambiguity in photo interpretation. Malfunctions in the probe should also be easily observed by aircraft personnel, allowing rapid decisions on the quality of the deployment. This, of course, will require longer on-station time.

A more sophisticated probe has been developed which permits the determination of differences between surface current and currents averaged over three preselected subsurface layers. This probe would be ideal for future experiments. The relative movement of an iceberg to the surface currents as indicated by iceberg wakes requires investigation of the sub-surface currents. The more sophisticated probe has this capability.

A capability to rapidly process the film should be investigated. This could result in an improved basis for an on-scene decision to repeat a test series. Failures in the camera or photographic techniques would also be quickly identified. In addition, an estimated float separation should be made and recorded on the data sheet during the photographic run.

Reference

Broida, S. and W.S. Richardson, 1972. Surface Current Measurements by Expended Probes, U.S. Coast Guard Technical Report Project 726520, June 1972: 7p.

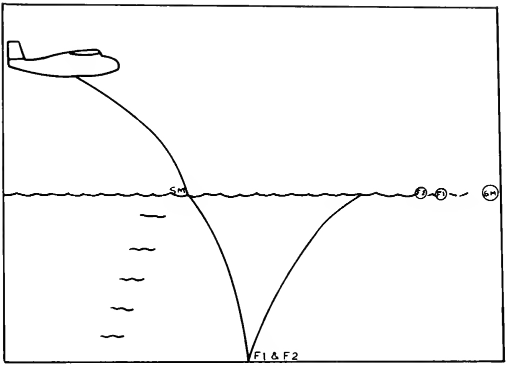

Figure 1
Use of Probe From Aircraft
(Broida and Richardson, 1972)

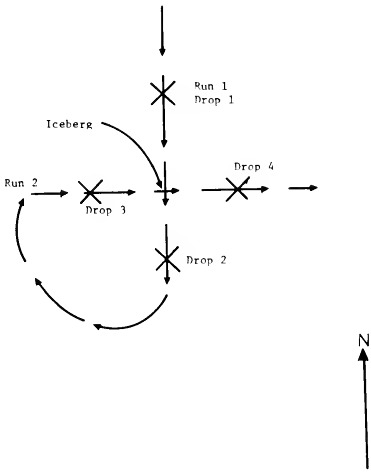

Figure 2
Flight pattern for deployment and photography
of surface current measurements probes.